Australian Government
Department of Climate Change

Australia's Fifth National Communication on Climate Change

A report under the United Nations Framework Convention on Climate Change

2010

thinkchange

Published by the Department of Climate Change

ISBN: 978-1-921298-74-5

All currencies are in Australian dollars unless otherwise stated.

A copy of this document and other Department of Climate Change information appears on the department's website at www.climatechange.gov.au

December 2009

Contents

Ministerial foreword

Acting on the challenge of climate change is a priority for the Australian Government. We are implementing a comprehensive strategy aimed at reducing our emissions, adapting to unavoidable climate change and taking a leading role in developing global solutions.

The report, Australia's Fifth National Communication, details the progress we have made to date, both in Australia and overseas, as well as reporting on our obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

While Australia's contribution to global emissions is relatively small, around 1.5%, our per capita emissions are among the highest in the world and the highest among OECD countries.

We have already committed to reducing emissions to 60% below 2000 levels by 2050 and from 5 to 15% and 25% below 2000 levels by 2020, depending on the outcome of the current negotiations on a global agreement to limit emissions.

The comprehensive climate change strategy that the Australian Government has put in place will achieve these deep cuts in emissions while achieving strong growth in incomes and employment.

Our aim is to lead the world in showing that it is possible to decouple economic growth from rising emission levels.

The Carbon Pollution Reduction Scheme (CPRS)—Australia's emissions trading system—is the key to achieving this. By putting a price on carbon and imposing a legislated limit on emissions that reduces over time, polluters must pay to emit greenhouse gases, creating an incentive for them to take action.

The CPRS will link to international emissions trading schemes, reflecting the Australian Government's view that an effective global carbon market is central to the development of low-cost global solutions.

Our geography, coastal population concentrations and unique biodiversity mean that we are particularly vulnerable to climate change. More frequent and severe droughts, rising sea levels, declines in rainfall across southern Australia and reduced water availability are already a reality.

If global greenhouse gas emissions continue to rise unchecked, we will bear the impact of declines in agricultural and livestock production, falling tourist numbers and supporting our community through climate events such as droughts.

We must also act to protect our natural heritage. The destruction of sensitive ecosystems such as the Great Barrier Reef would be a loss not only for Australia but also for the planet.

Supporting the community to make a contribution to reducing emissions is also part of the Australian Government's strategy. Education programs for schools, homes and businesses have been put in place and there are incentives to help people move to renewable energy sources like solar.

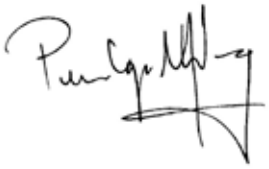
Our access to high-quality renewable energy sources provides enormous potential for the development of technologies such as geothermal, wave and large-scale solar generation. The Australian Government has introduced measures to support the uptake and development of renewable energy and expects the renewable energy sector to grow to around 30 times its current size by 2050. We have also invested heavily in industrial-scale carbon capture and storage projects to reduce emissions.

Well-targeted action on energy efficiency by households and business will deliver sustainable emissions reductions as well as cost savings. The Australian Government has collaborated with states and territories on the National Strategy on Energy Efficiency that drives action on commercial and residential buildings, households, transport and government action in its own operations.

We recognise that financial support and technology cooperation are essential to support actions by all countries to achieve global emissions reductions and to adapt to the unavoidable impacts of climate change.

Targeting support to build capacity in developing countries will enhance developing countries' ability to develop and implement domestic policies and measures, and increase access to international finance to support their efforts, including access to the carbon market.

The Australian Government has played an active and constructive role in efforts to secure a new, global agreement to tackle climate change. Australia will continue to play its full and fair part in international debate and action on key climate change issues.



Senator the Hon. Penny Wong
Minister for Climate Change and Water

CHAPTER 1

Executive summary

Australia's Fifth National Communication on Climate Change reports on Australia's recent action on climate change. For the first time, it also reports on supplementary elements required under the Kyoto Protocol.

As an Annex I signatory to the UNFCCC Australia is required to submit a national communication every four years. National communications are designed to provide a consistent, comparable, accurate and complete account of action being taken by Parties to the Convention to address climate change.

Australia's Fifth National Communication showcases Australia's comprehensive strategy to address the challenge of climate change and reflects the considerable progress made since the submission of its Fourth National Communication in 2005. Key developments since then are listed in the box below.

It also addresses the recommendations of the 2009 UNFCCC *Report of the In-Depth Review of the Fourth National Communication of Australia* through clearer presentation of the most significant policies and measures; more detailed information on the monitoring systems and institutional arrangements in place to support and deliver climate change policy, research and evaluation; and improvements in the quality and transparency of reporting on financial resourcing and technology cooperation actions.

Since the Fourth National Communication the Australian Government has put in place a comprehensive climate change strategy and has made significant progress on a number of key measures. The development of these approaches has been informed by extensive consultation with stakeholders and reflects the Government's commitment to the principles of evidence-based policy development.

These policies and measures were informed by considerable investment in research and analysis of ways to best address climate change issues, and with input from industry and the Australian public.

The Australian Government's climate change strategy is made up of three key pillars:

- reducing emissions
- adapting to unavoidable climate change
- helping to shape a global solution.

These three pillars provide a framework to ensure Australia delivers on its ambitious emissions reductions targets. A feature of the three-pillar strategy is a cap-and-trade emissions trading system known as the Carbon Pollution Reduction Scheme.

This is supported by a range of complementary measures to form a comprehensive climate change

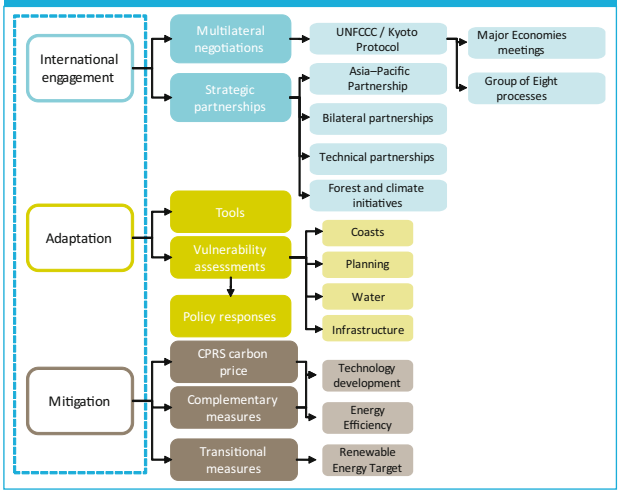
AUSTRALIA'S KEY ACHIEVEMENTS SINCE AUSTRALIA'S FOURTH NATIONAL COMMUNICATION ON CLIMATE CHANGE

- Ratification of the Kyoto Protocol in 2007
- Commitment to ambitious emissions reduction targets
- Development of the Carbon Pollution Reduction Scheme to put a price on carbon and achieve these targets
- Legislation passed to implement the expanded Renewable Energy Target so that 20% of Australia's electricity is sourced from renewables by 2020
- Legislation for a national greenhouse and energy reporting system to increase the accuracy of the National Greenhouse Gas Inventory, provide data to underpin the Carbon Pollution Reduction Scheme and reduce the reporting burden for industry
- Increased understanding of the earth's climate system through expanded research capacity
- Increased understanding of the impacts of climate change on Australian ecosystems and our coastline
- Establishment of the Global Carbon Capture and Storage Institute, which will accelerate the commercial deployment of at least twenty carbon capture and storage projects required to realise the valuable contribution that the technology can make to reducing carbon dioxide emissions
- Continued and enhanced investment in adaptation, mitigation, capacity building and technology cooperation throughout the Asia–Pacific region.

strategy that spans mitigation and adaptation and positions Australia to play a constructive role in the global effort to reduce climate change.

Australia's three-pillar climate change strategy is described in more detail in the box on page 4 and illustrated in Figure 1.1.

***Figure 1.1** Australia's three-pillar climate change strategy*



Australia's Fifth National Communication provides:

- a detailed description of Australia's national circumstances as context for Australia's approach to addressing climate change (Chapter 2)
- the most recent inventory of greenhouse gas emissions and the methodologies used to calculate these emissions (Chapter 3)
- details of progress on climate change policies and measures since Australia's Fourth National Communication (Chapter 4)
- detailed sectoral projections for Australia's greenhouse gas emissions (Chapter 5)
- evidence of Australia's vulnerability to climate change impacts and the planned and implemented actions to address those impacts (Chapter 6)
- Australia's approach to international financial resourcing to developing countries to assist them to address climate change issues and information on international technology cooperation (Chapter 7)
- details of progress by Australian research programs and institutions in climate research, systematic observation, and adaptation and mitigation technologies (Chapter 8)
- an update of action in Australia to raise skills and knowledge of climate change issues through awareness-raising education and training activities (Chapter 9).

1.1 Australia's national circumstances

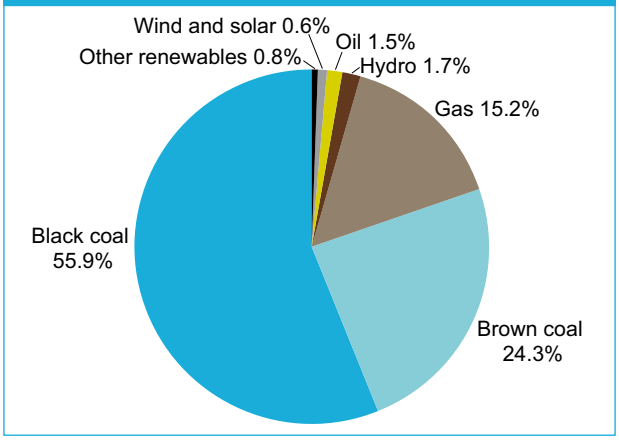
As one of the hottest and driest continents on Earth, Australia will be particularly adversely affected by climate change. Unmitigated climate change poses a significant threat to Australia's economic security, natural heritage and way of life.

Responsibility for addressing climate change in Australia is shared between three levels of government—the Australian Government, the governments of the six states and two territories and around 700 local government authorities. The Australian Government Department of Climate Change is the lead agency in the Australian Government's response to climate change.

Australia's population is relatively small, at around 21.8 million people; our contribution to total global greenhouse emissions is also relatively small, at around 1.5%. However, Australia's per capita greenhouse gas emissions are the highest of any OECD country and are among the highest in the world. This is due in part to the dominance of resource-based industries in our economy and its reliance on low-cost fossil fuels.

Australia is an open, export-led economy. The availability of low-cost coal, in particular, has led to a dominance of coal-fired electricity generation and energy-intensive industries (see Figure 1.2). These industries make a significant contribution to economic growth, employment and regional development in Australia.

***Figure 1.2** Fuel inputs to Australian electricity generation, 2007–08*



Source: ABARE 2009, *Australian Energy Statistics*.

SUMMARY OF AUSTRALIA'S THREE-PILLAR CLIMATE CHANGE STRATEGY

Australia's emissions reduction targets

The Australian Government has set ambitious targets to reduce Australia's greenhouse gas emissions:

- reduce emissions to 25% below 2000 levels by 2020 if the world agrees to an ambitious global agreement consistent with stabilising greenhouse gas levels at 450 parts per million or lower
- reduce emissions by up to 15% on 2000 levels by 2020 in the context of an international agreement where major developing economies commit to substantially restrain emissions, and advanced economies take on commitments comparable to Australia's, but global action falls short of stabilisation at 450 ppm or lower
- unconditionally reduce emissions to 5% below 2000 levels by 2020 regardless of the commitments and actions of other nations.

Pillar 1: Reducing emissions

The Australian Government has developed a comprehensive and integrated set of climate change policies and programs to ensure these targets are met, and to provide incentives for action to transform the Australian economy over time.

The Australian Government will establish an emissions trading system, the Carbon Pollution Reduction Scheme (CPRS) as the primary policy mechanism to reduce Australia's emissions by putting a price on greenhouse gas emissions.

The CPRS will be complemented by a range of measures designed to foster a low-emissions economy; support energy efficiency; reduce emissions from the transport, waste, land-use change and forestry sectors; foster carbon offsetting activities; assist with the transition to a low-emissions economy; and address emissions in sectors not directly covered by the CPRS such as agriculture, deforestation and government operations.

See Chapter 4 for further detail on the CPRS and complementary measures.

Pillar 2: Adapting to unavoidable climate change

The Australian Government is developing a comprehensive adaptation policy to prepare Australia to deal with the social, economic and environmental risks of climate change impacts, and is building capacity to adapt to the unavoidable impacts of climate change through a range of research initiatives, research facilities, and risk assessments.

The Australian Government's actions on adaptation have focused on building the tools and information needed to underpin sound decision making at a national level and coordinating the economic or regulatory reforms needed to address climate change risks. This important suite of measures will inform national planning, regulation and investment decisions.

See Chapter 6 for further detail on the impacts of climate change and our response to Australia's vulnerability.

Pillar 3: Helping to shape a global solution

Since ratifying the Kyoto Protocol in 2007 the Australian Government has played an active and constructive role in efforts to secure a new, global agreement to tackle climate change. Australia is continuing to lead international debate and action on key climate change issues.

In this respect, the Australian Government has set as its objective a fair and effective global climate change agreement delivering deep cuts in emissions to deliver long-term stabilisation of greenhouse gas emissions at 450 parts per million or lower.

The Australian Government has three priorities in shaping such a global response to climate change:

- a global goal: a clear constraint on global emissions which provides a strong incentive for countries to reduce emissions
- specific national commitments: economy-wide emissions reduction targets by all advanced economies and measurable, reportable and verifiable commitments to action by developing countries, taking into account the specific circumstances of each country
- helping the most vulnerable to adapt: effective mechanisms for funding and supporting adaptation for those countries least able to cope with climate change.

In addition, the Government is active in developing mechanisms to reduce emissions from forests in developing countries: deforestation accounts for approximately 18% of global greenhouse gas emissions and as such Australia has taken a leadership role in promoting the inclusion of deforestation in a post-2012 climate change agreement.

Australia has pursued its goals through active engagement in the UNFCCC, bilaterally with key partner countries and through high-level meetings on climate change that complement and help progress the UNFCCC agenda, including the Group of Twenty and the Major Economies Forum on Energy and Climate.

See Chapter 7 for further information on international financial resourcing to assist developing countries to address climate change issues and information on international technology cooperation.

Australia has one of the most naturally variable climates in the world (see Figure 1.3). With climate change, this variability will become more extreme in the future. Australia's geography, coastal population concentrations and biodiversity render it particularly vulnerable to small variations in climate.

Many of Australia's key industry sectors such as agriculture and tourism are also vulnerable to the high variability in temperature and rainfall patterns. If global greenhouse gas emissions continue to rise unchecked, Australia will experience further declines in agricultural production, as well as rising costs.

Ecosystems, the economy and Australian society are likely to be strongly affected by climate change. The analysis presented in the final report of the Garnaut Climate Change Review, a joint venture by the Australian Government and state and territory governments, builds a strong case for responding to climate change with mitigation action (Garnaut 2008).

1.2 Australia's National Greenhouse Gas Inventory

As a Party to the UNFCCC and the Kyoto Protocol, Australia has an obligation to prepare, publish and update greenhouse gas inventories on an annual basis. Since the Fourth National Communication, Australia has developed a range of measures to improve the national greenhouse gas inventory system and produce more accurate and comprehensive emissions estimates.

These measures, described in Chapter 3, include the adoption of new data and methods for estimation of greenhouse gas emissions and the implementation of national greenhouse and energy reporting legislation. Australia has also recently established the Australian National Registry of Emissions Units to meet Kyoto Protocol reporting requirements.

Australia's most recent inventory covers the year 2007 and was submitted to the UNFCCC Secretariat in 2009 in accordance with the mandated reporting timeframes. The inventory results for the period between 1990 and 2007 are summarised below and illustrated in Figure 1.4.

In 2007, Australia's total greenhouse gas emissions—excluding the land use, land-use change and forestry (LULUCF) sector—were 541.2 million tonnes (Mt) carbon dioxide equivalent (CO_2-e). Stationary energy, transport and fugitive emissions from fuels dominate Australia's emissions profile, contributing 75.4% of total emissions in 2007 (see Figure 1.5). The agriculture sector is also a significant contributor to Australia's emissions profile at 16.3%. Emissions from the industrial processes and waste sectors are relatively minor.

According to the accounting provisions of the UNFCCC, Australia's total greenhouse gas emissions (excluding the LULUCF sector) have increased by 30% between 1990 and 2007. When the LULUCF sector emissions and removals are included, Australia's net greenhouse gas emissions in 2007 have increased by 82% compared with 1990 levels.

***Figure 1.3** Annual rainfall variability in Australia (percentile analysis relative to 30-year 1961–90 long-term average)*

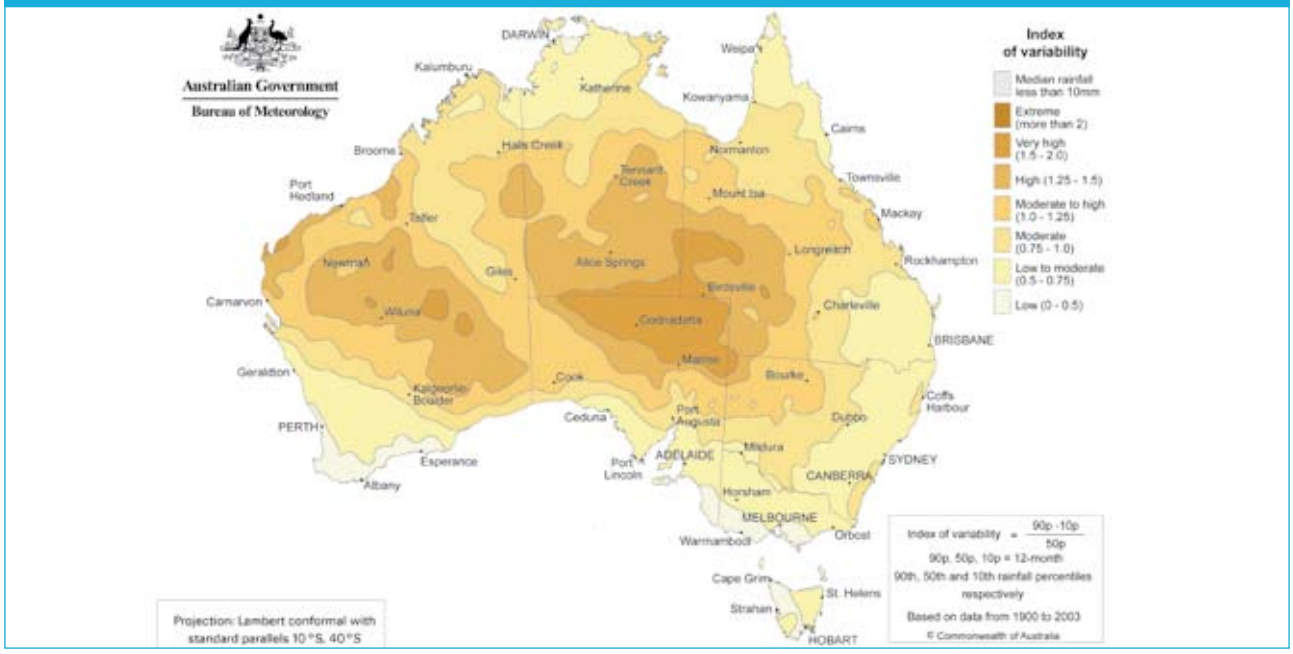


Figure 1.4 *Trends in CO_2-e emissions and removals by sector in Australia, 1990 to 2007*

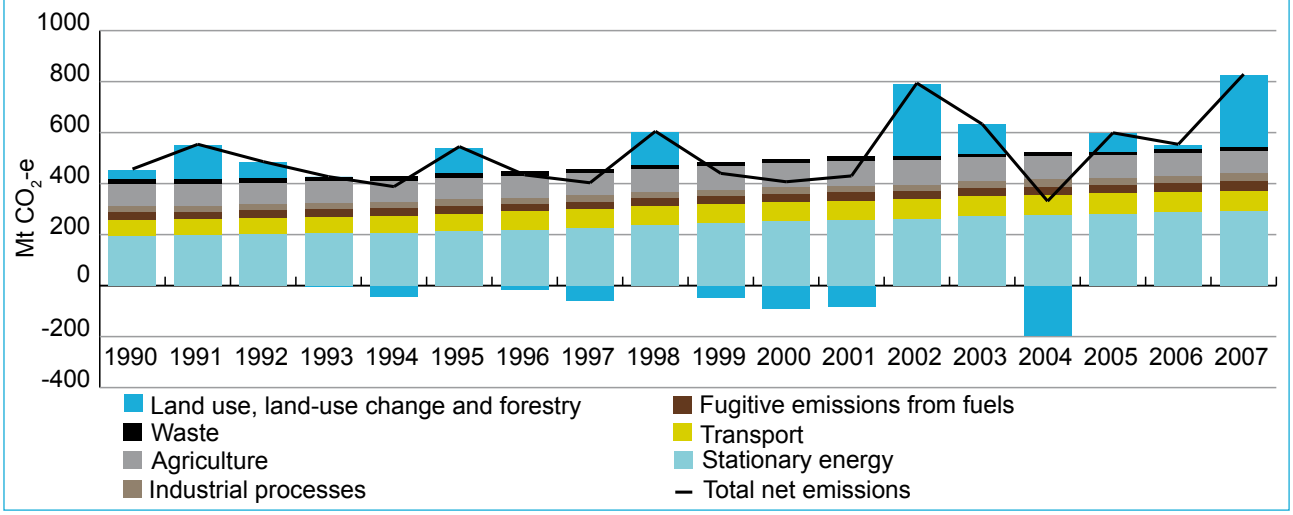
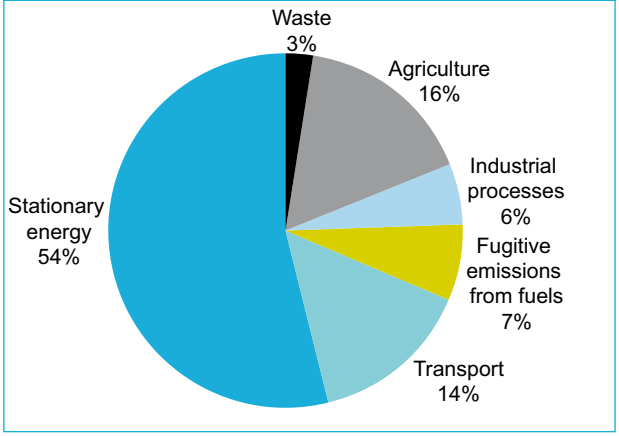


Figure 1.5 *Contribution to total CO_2-e by sector in Australia, 2007 (excluding LULUCF)*



Sectors with increasing emissions over the period between 1990 and 2007 included stationary energy, transport, fugitive emissions from fuels, industrial processes, agriculture and LULUCF. Waste emissions decreased over this same period.

In 2007 carbon dioxide had the largest share of the greenhouse gases in Australia's inventory, at 81.7% of total CO_2-e emissions, followed by methane, which comprised 14.5%. The remaining gases made up 3.8% of Australia's greenhouse gas emissions.

Total emissions estimated using the UNFCCC accounting provisions generate a highly volatile data series. In 2007 alone, emissions increased by 61 percentage points, from 21% above 1990 levels to 82% above 1990 levels. Such volatility reflects data from a number of highly unpredictable categories that are not included within the scope of the Kyoto Protocol, such as changes in soil carbon induced by weather events or forest fires. The latest published data for Australia's net greenhouse gas emissions, estimated according to the accounting provisions of the Kyoto Protocol, show emissions at 7% above 1990 levels in 2009. The projections of emissions reported in Chapter 5 have also been prepared on this basis.

1.3 Policies and measures

Since its Fourth National Communication on Climate Change, Australia has established a comprehensive and targeted set of policies and measures to meet current and future commitments to reduce its greenhouse gas emissions.

Chapter 4 describes the major policies and measures being developed and implemented by the Australian Government to meet Australia's ambitious emission reduction targets. The Carbon Pollution Reduction Scheme (CPRS) is the Australian Government's key mechanism for reducing emissions. The CPRS is a cap-and-trade emissions trading system that will for the first time establish a price on carbon. The CPRS will be complemented by a range of measures delivered by all levels of government to effect the transition to a low-emissions economy. The CPRS and key complementary measures are described below.

As well as the measures themselves, Chapter 4 outlines the policy context and policy-making processes that underpin Australia's climate change policy framework. It includes a description of the extensive independent analysis undertaken over 2007 and 2008 to inform development of Australia's approach to reducing emissions.

1.3.1 The Carbon Pollution Reduction Scheme

The Australian Government has developed an emissions trading system—known as the Carbon Pollution Reduction Scheme, or CPRS—to be the primary mechanism for reducing Australia's greenhouse gas emissions. The CPRS is to be a legislative cap-and-trade emissions trading system that is specifically designed for Australia's national circumstances. It is one of the most comprehensive in the world, covering around 75% of Australia's emissions.

The CPRS has been designed to link to other international emissions trading schemes, on the basis that an effective global carbon market is central to the development of sound international solutions to climate change and will foster least-cost global abatement.

The CPRS will apply obligations to businesses with facilities that meet a threshold of emissions, as well as businesses that import, manufacture or supply certain fuels and synthetic greenhouse gases. Early estimates suggest that the CPRS will directly involve around 1000 businesses and other organisations in Australia.

The CPRS will commence on 1 July 2011, with a one-year transitional fixed-price period in which Australian emissions units will be available for $10. The Australian Government will auction the majority of Australian emissions units from the commencement of normal trading (where the market sets the price) on 1 July 2012. The CPRS will be administered by an independent statutory authority—the Australian Climate Change Regulatory Authority.

The CPRS legislation was defeated in the Australian Parliament twice during 2009. Reflecting its commitment, the Government has indicated it will reintroduce the bills on the first parliamentary sitting day in 2010.

1.3.2 Key measures to complement the CPRS

To complement the CPRS, Australia is implementing an extensive and well targeted range of policies and measures to assist in reducing Australia's greenhouse gas emissions.

The Council of Australian Governments has endorsed a set of 'complementarity principles' to guide Australian jurisdictions in reviewing and streamlining their existing climate change mitigation measures to create a coherent and streamlined set of climate change measures.

Measures designed to complement the CPRS are described in Chapter 4, and include:

- measures to deploy existing clean energy and low-emissions technologies such as the 20% by 2020 Renewable Energy Target
- additional support for the creation of new clean energy and low-emissions technologies and products through the Clean Energy Initiative and the Global Carbon Capture and Storage Institute
- measures to improve energy efficiency in Australian homes, shops, offices and workplaces including through measures incorporated in the National Strategy on Energy Efficiency
- opportunities for Australian households to engage in individual action through the Energy Efficiency Savings Pledge Fund in the Australian Carbon Trust
- transitional measures to help business and community groups prepare for a low-emissions future through the Climate Change Action Fund.

In August 2009, the Australian Government passed laws to implement an expanded national Renewable Energy Target (RET) of 20% of Australia's electricity supply from renewable energy sources by 2020. The RET increases the previous Mandatory Renewable Energy Target more than fourfold—from 9500 gigawatt hours to 45 000 gigawatt hours in 2020—and will create incentives for a range of technologies including wind, biomass, geothermal and solar energy.

The Council of Australian Governments has agreed to a comprehensive 10-year National Strategy on Energy Efficiency to accelerate energy efficiency improvements for householders and businesses across all sectors of the economy. The strategy will provide a nationally consistent and coordinated approach to energy efficiency. The strategy is designed to complement the CPRS by addressing information, organisational and other non-market barriers.

The Australian Government is establishing a $2 billion Climate Change Action Fund to assist businesses, community sector organisations, workers, regions and communities to make the transition to a low-emissions economy by providing information and financial assistance. The fund will operate over seven years, from 2009–10 to 2015–16.

The Australian Government's $4.5 billion Clean Energy Initiative furthers innovation in clean energy generation and supports the research, development and demonstration of low-emissions technologies, including industrial-scale carbon capture and storage, solar energy, and non-solar renewable technologies.

The Australian Government announced the establishment of the Global Carbon Capture and Storage Institute in September 2008 and has committed $100 million per annum over the medium term to help deliver the Group of Eight's July 2008 agreed goal of developing at least 20 fully integrated industrial-scale demonstration projects around the world to accelerate the broad deployment of carbon capture and storage technology by 2020. The institute comprises 131 foundation members, including 23 national governments and more than 100 companies and organisations.

1.4 Greenhouse gas emissions projections

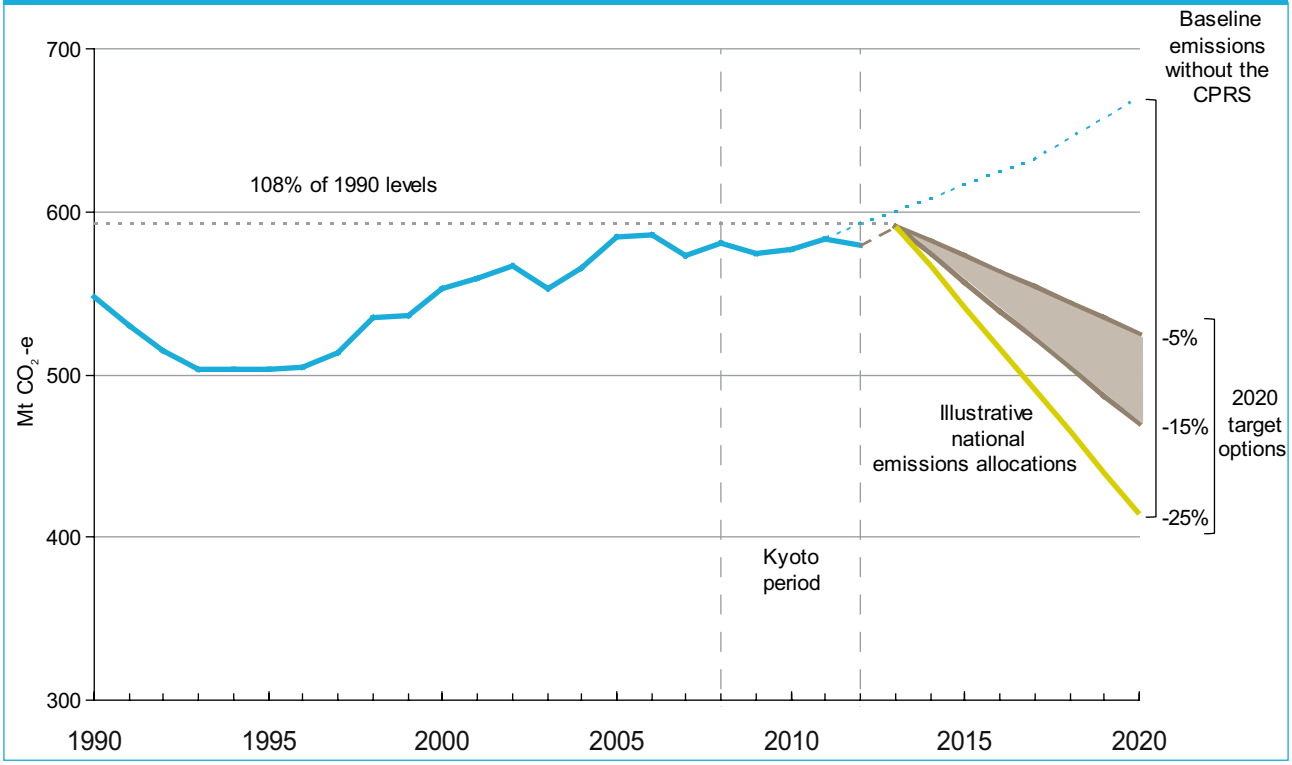
Chapter 5 presents sectoral projections for Australia's greenhouse gas emissions that were prepared in 2009. Baseline greenhouse gas emissions projections show the projected effect of emissions reduction policies and measures on Australia's emissions. The projections are provided for each National Greenhouse Gas Inventory sector, focusing on 2010 and 2020.

Projections are made in accordance with the UNFCCC and the Kyoto Protocol requirements. The Australian Government Department of Climate Change has an ongoing program to update and improve sectoral projections.

Updated sectoral projections together with the impact of mitigation policies and measures show that Australia remains on track to meet its Kyoto Protocol target of limiting emissions to 108% of 1990 levels without the use of flexibility mechanisms or imported emissions permits. Australia's emissions on a Kyoto Protocol accounting basis are projected to reach an average of 581 Mt CO_2-e per year over the first commitment period (2008–12), which is 106% of 1990 levels. Projections made using UNFCCC accounting rules are also detailed in Chapter 5.

In the absence of the Australian Government's key mitigation measure, the CPRS, baseline emissions in Australia are projected to increase. Figure 1.6 shows that, in 2020, baseline emissions without the CPRS are projected to be 669 Mt CO_2-e on Kyoto accounting rules, equivalent to 121% of 2000 levels. This provides a measure of the amount of additional abatement or avoided emissions that are required to achieve Australia's 2020 emissions reduction targets, given the policies and measures that are already in place.

Figure 1.6 Summary of Australia's emissions projections



Source: Unpublished Department of Climate Change analysis 2009.

The baseline emissions projection is a 'with measures' scenario that incorporates all currently implemented and adopted policies and measures. This takes into account a projected 147 Mt CO_2-e of abatement from existing policies and measures in 2020, including at least 73 Mt CO_2-e from energy efficiency and renewable energy policies, and 18 Mt CO_2-e of abatement from policies restricting land-use change. Analysis indicates that these existing policies and measures are not capable of delivering significant further low-cost abatement, although some—such as energy efficiency measures—would be expected to deliver more abatement if reinforced by a broad-based incentive, such as the carbon price provided by the CPRS.

Australia's 'business as usual' emissions are also projected, excluding all policies and measures to reduce emissions since 1990. It is estimated that emissions under this scenario would have risen from 631 Mt CO_2-e in 2007 to 816 Mt CO_2-e in 2020.

1.5 Climate change vulnerability and adaptation

Australia is already experiencing the early impacts of climate change and will face more substantial impacts in the future. Higher temperatures, more frequent and severe weather events, and a further decrease in rainfall and water availability could lead to major declines in agricultural production, damage to natural marine ecosystems, and damage to coastal infrastructure.

Developing a comprehensive understanding of the impacts of climate change on Australia is essential to assessing the exposure, risks and opportunities arising from climate change and the development of evidence-based policy responses. While Australia needs to continue to build its understanding of climate change, some indication of the potential impacts and costs to Australian industries, environment, people and infrastructure is emerging, as described in Chapter 6.

Under the second pillar of the Australian Government's climate change strategy, adapting to unavoidable climate change, the Australian Government has focused on providing the information and tools needed to underpin sound decision making and coordinating the economic and regulatory reforms needed to better address climate change risks at the national level. State, territory and local governments have focused their initiatives at the regional level and have the major role in direct adaptation action.

Since the Fourth National Communication, all levels of government in Australia have initiated a range of programs and initiatives that improve Australia's capacity to adapt to the impacts of climate change and facilitate adaptation responses in highly vulnerable sectors and regions. There has been considerable investment in the knowledge and tools needed to deliver adaptation responses. Australian governments have funded research on the impacts of climate change, undertaken vulnerability assessments and implemented adaptation measures in key vulnerable sectors and regions.

The Australian Government has undertaken a number of strategic national vulnerability assessments including assessments of climate change risks to Australia's coasts, biodiversity, national infrastructure and Indigenous communities.

The vulnerability assessments to date have revealed a wide range of likely impacts on Australia:

- decreased water availability and water security
- coastal zone impacts such as inundation from sea-level rise
- damage to energy, water, communications and built infrastructure
- a decline in agricultural productivity
- damage to iconic natural ecosystems
- a decline in biodiversity.

In 2007 the Council of Australian Governments endorsed the National Climate Change Adaptation Framework to guide practical activities over the next five to seven years. Adaptation actions by governments have been guided by priorities identified in the framework.

To assist local governments enhance their capacity to prepare for and respond to climate change impacts, the Australian Government has provided funding for climate change risk assessments and actions to prepare for the likely local impacts of climate change. The Government is also continuing to support adaptation research across a range of areas, including urban coastal vulnerability, national reserves, health impacts and primary industries.

1.6 Financial resources and technology cooperation

As part of the third pillar of Australia's climate change strategy, helping to shape a global solution, the Australian Government is assisting other countries to address climate change (Chapter 7). Finance and technology cooperation are essential to support actions by all countries to achieve global emissions reductions consistent with stabilisation at or below 450 ppm and to adapt to the impacts of climate change.

Australia's approach to climate change financing and technology cooperation recognises that early action on both adaptation and mitigation will reduce global costs and the costs to individual countries. Australia also recognises that targeting support to build capacity in developing countries will enhance their ability to implement domestic policies and measures, and increase access to international finance to support their efforts, including through the carbon market.

Australia's priorities for climate change finance and technology cooperation include:

- supporting adaptation in the most vulnerable countries, particularly countries in the Asia–Pacific region
- creating enabling environments for private sector investment
- addressing market failures
- facilitating improved access to international finance to support domestic efforts
- facilitating the transformation of economies in areas where market-based approaches do not reach, such as through research, development and demonstration of low-emissions technologies.

The Australian Government has taken steps to improve the quality and transparency of reports on financial and technology actions in this national communication. One such step has been to improve the clarity of categories of assistance Australia has provided to developing countries.

Many of Australia's adaptation, mitigation, capacity-building and technology cooperation programs are administered through bilateral partnerships. However, a large proportion of Australia's climate change financing and technology cooperation is distributed through multilateral organisations such as the Global Environment Facility and the World Bank.

Key bilateral and multilateral activities include support for efforts to reduce emissions from deforestation and forest degradation in developing countries, and support for the development and deployment of industrial-scale carbon capture and storage technology, in Australia and abroad.

Australia participates in high-level meetings on climate change that complement and help progress the UNFCCC agenda, including the Group of Twenty and the Major Economies Forum on Energy and Climate.

Australia has provided a total of approximately $476 million of new and additional financial resources for climate change programs in developing countries since the Fourth National Communication.

Recent developments in Australia's approach to financial resources and technology cooperation have included:

- establishment of the Global Carbon Capture and Storage Institute through a commitment made in 2008 to provide $400 million in funding over four years to help deliver the Group of Eight's goal of developing at least 20 fully integrated industrial-scale carbon capture and storage demonstration projects around the world
- investment of $200 million over five years (2007–08 to 2011–12) through the International Forest Carbon Initiative to demonstrate that reducing emissions from deforestation and forest degradation in developing countries (REDD) can be part of an equitable and effective post-2012 global climate change agreement
- investment of $150 million over three years (2008–09 to 2010–11) through the International Climate Change Adaptation Initiative to meet high-priority climate adaptation needs in vulnerable countries in the Asia–Pacific region
- provision of $100 million over three years (2008–09 to 2010–11) to support the World Bank Clean Technology Fund, which seeks to promote scaled-up financing for demonstration, deployment and transfer of low-carbon programs and projects with a significant potential for long-term greenhouse gas emissions savings.

1.7 Research and systematic observation

Australia has the most comprehensive research and monitoring activities related to climate change in the southern hemisphere, focusing on four main areas: process studies, climate models, emissions reduction technologies and systematic observation.

Chapter 8 outlines how Australian climate change scientists continue to play an active role in research on climate and climate change through participation in international scientific committees and ongoing contributions to global climate change research.

Research by Australian institutions and scientists, for example, has contributed significantly to the climate change assessments of the Intergovernmental Panel on Climate Change including through the 2007 Fourth Assessment Report and the upcoming Fifth Assessment Report. Australia is also a member of key international climate change research and information exchange programs and organisations and participates in a range of international research networks.

Key developments in research and systematic observation since the Fourth National Communication include:

- establishment in May 2009 of the National Framework for Climate Change Science to bring together Australia's climate change expertise so as to deliver the essential science needed for an effective national response to climate change
- release in October 2007 of *Climate Change in Australia: Technical report 2007*, an up-to-date assessment of observed climate change in Australia, the likely causes, and projections of future changes to Australia's climate. This report was produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Government Bureau of Meteorology following the release of the Fourth Assessment Report of the IPCC
- establishment of a $1.1 billion Super Science Initiative, where the Australian Government is investing $387.7 million in research infrastructure to improve Australia's ability to respond to climate change
- allocation by the Australian Government of $400 million for research infrastructure related to the Clean Energy Initiative
- development of an internationally competitive climate modelling system, the Australian Community Climate and Earth-System Simulator (ACCESS) by the Centre for Australian Weather and Climate Research. ACCESS is now operational for weather prediction and by 2011 it will provide long-term global and regional climate projections and a key platform for Australia's contributions to the IPCC Fifth Assessment Report
- delivery of updated estimates of ocean warming and sea-level rise by the Antarctic Climate and Ecosystems Cooperative Research Centre showing that, since 1961, the trend in thermal expansion has been 50% larger than previous estimates. There is now agreement between the observed variability in thermal expansion and the ocean warming inferred from global climate models.

1.8 Education, training and public awareness

Information and education are fundamental to building broad support for climate change policies. The Australian Government recognises that a diverse range of information and education approaches are required to reach the broad range of audiences interested in, or affected by, climate change and climate change policies. These are described in Chapter 9. Information and education approaches are tailored to cater for and reach all relevant audiences.

Australian governments at all levels have developed public awareness and education programs to communicate the need to change behaviours that contribute to climate change through stakeholder engagement, education, training and professional development.

Information networks provided by schools, universities, vocational training and public information portals such as the internet and television have been harnessed to increase awareness and understanding of government policies on climate change, energy efficiency and other mitigation activities. A range of non-government organisations also promote public awareness and understanding of climate change through research, lobbying, education, training and media activities.

The Australian Government and state and territory governments are working to identify skill needs, reform training products, and deliver training to upskill and reskill the workforce. These measures will build the capacity of the workforce to respond to climate change and transition to a low-carbon economy.

Australia shares its experiences and knowledge in implementing climate change policies to assist other countries, in particular developing countries, to measure and manage their emissions, reduce emissions from key sectors and adapt to the unavoidable impacts of climate change. Australia

recently led the development of a whole-of-government Pacific climate change policy to guide Australia's engagement with Pacific island countries on climate change to 2015.

Key developments in education, training and public awareness since the Fourth National Communication on Climate Change include:

- reforms and program delivery through Australia's formal education system and the vocational education and training sector to ensure that Australia's current and future workforce will be equipped with the ingenuity, skills and knowledge to respond to climate change and to facilitate the transition to a low-carbon economy
- a significant increase in support for research to improve the capacity of developing countries to prepare for the impacts of climate change. AusAID support for research relating to climate change rose from $1.5 million in 2006–07 to more than $6 million in 2008–09. The support is provided through a suite of programs and initiatives.

References

ABARE (Australian Bureau of Agricultural and Resource Economics) 2009, *Australian Energy Statistics*.

Australian Greenhouse Office within the Department of the Environment and Heritage 2005, *Australia's Fourth National Communication on Climate Change: A Report under the United Nations Framework Convention on Climate Change*, Commonwealth of Australia, Canberra.

Garnaut, R 2008, *The Garnaut Climate Change Review: Final report*, Cambridge University Press, Melbourne.

UNFCCC 2009, *Report of the In-Depth Review of the Fourth National Communication of Australia* FCCC/IDR.4/AUS, 20 January 2009, available at http://unfccc.int.

CHAPTER 2

Australia's national circumstances

AUSTRALIA'S KEY FEATURES

The United Nations Framework Convention on Climate Change (UNFCCC) recognises that all parties have a common but differentiated responsibility to address climate change. The Convention further recognises that each party is unique and therefore its climate change response strategy must be tailored to suit its particular circumstances.

This chapter describes Australia's national circumstances and outlines the opportunities and constraints that Australia faces in engaging in action on climate change. These include the government structure, demographic profile, economy, energy production and consumption profiles, industries, transport, climate, landscape, urban structures and waste.

Climate, ecosystems, society and the economy are closely linked. Australia's infrastructure, towns and cities, and food production are all influenced by its historic experiences of long-term climate patterns—for example, the frequency of storms, the height of tidal surges, or rain and temperature patterns. Ecosystems, the economy and ultimately Australian society are therefore likely to be strongly affected by climate change. Analysis presented in the final report of the Garnaut Climate Change Review builds a strong case for responding to climate change with mitigation action. It concludes that 'the costs of well-designed mitigation, substantial as they are, would not end economic growth in Australia, its developing country neighbours, or the global economy. Unmitigated climate change probably would' (Garnaut 2008: 268).

While Australia's contribution to total global greenhouse emissions is relatively small, at around 1.5%, its per capita greenhouse gas emissions are the highest of any country in the Organisation for Economic Co-operation and Development (OECD) and are among the highest in the world. In 2008, Australia's per capita emissions (including emissions from land use, land-use change and forestry) were 27.4 tonnes carbon dioxide equivalent (CO_2-e) per person (DCC analysis 2009). Australia's per capita emissions were nearly twice the OECD average and more than four times the world average of six tonnes.

Australia's relatively high CO_2-e emissions per person can be attributed to factors such as the prevalence of low-cost coal in electricity generation, historical emissions from land clearing and the production of resource and agricultural products for export. Australian industry and consumers also depend heavily on long-haul transport, due to the wide dispersal of natural resources and Australia's remoteness from overseas markets.

Australia has traditionally sourced most of its energy from its extensive reserves of fossil fuels. The availability of coal in particular has led to a dominance of coal-fired electricity generation and energy-intensive industries such as aluminium smelting, iron and steel production, and cement and concrete industries. These industries make a significant contribution to GDP, employment and regional development in Australia.

Australia has a relatively high rate of population growth compared to other OECD countries. Australia's population is projected to continue to grow strongly out to 2020 (around 20% from 2008). Population growth is a strong driver of emissions growth and contributes to Australia's projected emissions growth of around 15% to 2020 (without the Carbon Pollution Reduction Scheme).

These characteristics of Australia's economy and its greenhouse gas emissions profile mean that Australia faces high economic costs relative to those of most other developed countries in setting its economy on a low-emissions pathway.

Even if climate change can be contained to around 2°C of global warming, Australia will have to manage serious and pervasive risks from climate change impacts. Water resources, natural ecosystems, coastal settlements and infrastructure are particularly vulnerable.

The Australian Government has taken into account these national circumstances in formulating Australia's response to climate change, which is based on a three-pillar approach of:

- reducing Australia's greenhouse gas emissions
- adapting to climate change that cannot be avoided
- helping to shape a global solution.

This framework (which is presented in more detail in the box on page 16) recognises that Australia needs both to contribute to finding an effective global solution and to prepare now to manage the transition to a low-emissions future. It is an approach consistent with the findings of economic modelling which suggests that near-term mitigation enhances global welfare in the longer term. It also recognises that economic, social and environmental decisions are being made daily that have the potential to increase Australia's exposure to a changing climate.

AUSTRALIA'S CLIMATE CHANGE STRATEGY

To help Australia combat climate change and prepare for its effects, the Australian Government has implemented a three-pillar policy approach: reducing Australia's carbon pollution; adapting to unavoidable climate change; and helping to shape a global solution.

Pillar 1: Reducing emissions

The Australian Government has developed an integrated policy program to reduce Australia's greenhouse gas emissions and enable Australia to achieve more ambitious reductions over the long term, including a 2020 target of 5 to 15% and 25% reduction in emissions on 2000 levels, and a 2050 target of 60% below 2000 levels.

To guarantee that Australia's emissions target is achieved, the Government will place a price on carbon by implementing a cap-and-trade emissions trading system (the Carbon Pollution Reduction Scheme), and transform energy supply through the Renewable Energy Target. The Government is also making significant investments in the development of new clean-energy technologies for the future and encouraging the deployment of existing climate change solutions such as energy efficiency and renewable technologies.

Pillar 2: Adapting to unavoidable climate change

Even if global mitigation efforts are successful, the science shows that some climate change impacts are unavoidable. Those impacts create considerable risks to Australia's assets, investments, environments, communities and regional economies. Action now to adapt to these unfolding challenges can reduce costs in the future.

The Australian Government is developing a comprehensive adaptation policy to prepare Australia to deal with the social, economic and environmental risks of climate change. Australia is already experiencing the early impacts of climate change and will face more substantial impacts in the future. Higher temperatures, sea-level rise, more frequent and severe weather events and a further decrease in rainfall and water availability could lead to damage to natural ecosystems such as marine reefs, major reductions in water resources and damage to coastal infrastructure.

The three key elements of the Government's approach to adaptation are:

- improving the knowledge and skills base to respond to the risks of climate change impacts
- assessing specific areas of vulnerability such as the coastal zone, our national infrastructure and agricultural production
- developing adaptation policy, including with all levels of government, business and the community.

Pillar 3: Helping to shape a global solution

The third pillar recognises that climate change is a global problem that requires a global solution. An important Australian objective for a global framework beyond 2012 is to ensure that this framework will slow and ultimately reduce greenhouse gas emissions to avert dangerous climate change.

The Australian Government has three priorities in shaping a global response to climate change:

- a global goal: a clear constraint on global emissions which provides a strong incentive for countries to reduce emissions
- specific national commitments: economy-wide emissions reduction targets by all advanced economies and measurable, reportable and verifiable commitments to action by developing countries, taking into account the specific circumstances of each country
- helping the most vulnerable to adapt: effective mechanisms for funding and supporting adaptation for those countries least able to cope with climate change.

International cooperation on the development and deployment of low-carbon technologies will also be an essential component of a strong global outcome. Australia is actively involved in a range of initiatives on technology and policy to mitigate greenhouse gas emissions.

Deforestation is a significant global source of emissions. The Australian Government is working closely with neighbouring countries, in particular Indonesia and Papua New Guinea, to find practical ways to reduce emissions from deforestation and forest degradation in developing countries. It is important to provide economic incentives for developing countries to reduce global deforestation, with deforestation accounting for approximately 18% of global greenhouse gas emissions.

2.1 Australia and its people

Mainland Australia, with a land area of 7.7 million sq km, is the world's largest island, but smallest continent. It spans about 3700 km from north to south and 4000 km from east to west. In area, Australia is the sixth largest country in the world after Russia, Canada, China, the United States and Brazil. Its ocean territory—the third largest in the world—spans three oceans and covers around 12 million sq km.

Australia's population is small relative to its physical size. There were 21.8 million people in March 2009. For the year ending March 2009, the population had increased by 2.1%, which is significant when compared with the 1.2% growth rate recorded five years previously. The last time Australia saw higher growth rates was in the 1950s and 1960s as a result of post-war migration and high birth rates. All states and territories experienced population growth over the 12 months to 31 March 2009, particularly Western Australia, where population growth reflected growth in the mining industry.

Australia's population is projected to continue to grow strongly out to 2020 (around 20% from 2008). Population growth is a strong driver of emissions growth and contributes to Australia's projected emissions growth of around 15% to 2020 (without the Carbon Pollution Reduction Scheme).

Australia has one of the most urbanised populations in the world—in 2007, 68.6% of the population lived in Australia's major cities. More than 80% of Australians live within 100 km of the coastline, and just over 2% in remote or very remote inland areas.

Responsibility for governing Australia is shared between three levels of government—the federal Australian Government, the governments of the six states (New South Wales, Victoria, Queensland, Western Australia, South Australia and Tasmania) and two territories (the Australian Capital Territory and the Northern Territory) and about 700 local government authorities. Local government bodies are created by legislation at the state and territory level.

Australia has a written constitution that sets out the functions of the Australian Government, such as foreign relations and trade, defence and immigration. States and territories are responsible for matters not assigned to the federal government. In practice the two levels of government cooperate in many areas.

The Council of Australian Governments (COAG) is the peak intergovernmental forum for interjurisdictional cooperation in Australia, and comprises the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association. The role of COAG is to initiate, develop and monitor the implementation of policy reforms that are of national significance and which require cooperative action by Australian governments. This includes cooperation, integration and implementation of climate change policy.

In addition, over 40 sector-specific ministerial councils facilitate consultation and cooperation between the Australian Government and state and territory governments in specific policy areas. These councils may develop policy reforms for consideration by COAG, and oversee the implementation of policy reforms agreed by COAG. Responsible ministers from the state and territory governments and the Australian Government participate in the councils.

Climate change issues requiring national coordination are managed through a number of ministerial councils, including:

- the Ministerial Council on Energy
- the Ministerial Council on Mineral and Petroleum Resources
- the Ministerial Council for Police and Emergency Management
- the Tourism Ministers' Council
- the Australian Transport Council
- the Natural Resource Management Ministerial Council
- the Local Government and Planning Ministers' Council.

The Australian Government Department of Climate Change is the lead agency in the Australian Government's response to climate change. The department is responsible for policy advice, implementation, and program delivery in the three pillar areas of mitigation, adaptation and international engagement.

2.2 Economy

As a result of nearly three decades of structural and policy reforms, the Australian economy is increasingly integrated with global markets. Australia has progressively dismantled or cut tariffs and now has low barriers to international trade and investment. Microeconomic reforms in the early 1990s have created substantial competition across the economy,

including in key areas such as the energy generation, financial, air transport and telecommunications sectors.

Australia's economy has grown at an average annual rate of 3.6% (based on July–June financial years) for over 15 years, well above the OECD average of 2.2%. In 2008–09, Australia's gross domestic product (GDP) was $1.2 trillion, an increase of 1.2%. This growth rate, the lowest since 1991–92, is due to the effects of the global economic slowdown.

Australia's strong economic growth has boosted domestic living standards and consumption. In 2008–09, Australia's GDP per capita was around $55 300 in real terms, down 0.7% from the previous financial year. This decrease in GDP per capita, the first since 1991–92, reflects the effects of the global economic slowdown. Over the medium term, rising per capita incomes in developing economies, further global trade liberalisation and economic integration are expected to continue to increase the demand for Australia's commodity exports and maintain the pattern of trade with growing Asia–Pacific markets.

2.3 Energy

Australia is the world's eighth largest energy producer, accounting for 2.4% of the world's energy production. Australia's energy production is dominated by coal production, which accounts for just over half of total energy production, followed by uranium and natural gas. Crude oil and liquefied petroleum gas (LPG) represent around 6% of total energy production. Renewables represent approximately 2% total energy production but are expected to grow considerably to meet the national expanded Renewable Energy Target. Australia's mining industry contributed 8% to Australia's GDP in 2008–09.

Australia has an abundant and diverse resource endowment, including extensive reserves of coal, natural gas and the world's largest resource of uranium that can be recovered at low cost. Australia is also exploiting current and emerging renewable energy sources.

Unlike many OECD countries, Australia is a net energy exporter. High-contract prices in place until the end of March 2009 and the depreciation of the Australian dollar in mid-2008 contributed to a forecast increase in the value of Australia's 2008–09 energy exports of 72%, from $43 to $75 billion (ABARE 2009b). Export values have been volatile and are projected to remain so in the short term.

2.3.1 Fuel types

Coal

Australia has a substantial coal resource, with significant reserves of both black and brown coal. A large proportion of Australian black coal resources are high-quality bituminous coals, characterised by low sulphur and low ash content. As at December 2008, Australia had demonstrated black coal resources of around 67 billion tonnes, of which around 39 billion tonnes were considered economically recoverable. Economically recoverable brown coal resources are currently estimated at 37.2 billion tonnes, or 25% of the world's economic demonstrated resources. The proportion of economic demonstrated resources to current production is estimated at 500 years for brown coal and 100 years for black coal.

The coal industry is Australia's largest export sector. Coal provides more than half of Australia's energy export trade, with more than 80% of Australia's black coal production destined for export. The world's continued reliance on coal has led Australia to commit to investment in industrial-scale carbon capture and storage projects to reduce carbon dioxide emissions.

Oil

Australia has relatively small oil and gas resources and is a net importer of crude oil and refined petroleum products. Australia's oil and gas resources encompass crude oil, condensate and naturally occurring LPG. The proportion of crude oil reserves to current production is estimated at between eight and 10 years. In the absence of major new discoveries, oil production in Australia will continue to decline due to the maturity of Australia's current producing areas.

Natural gas

Australia has significant natural gas resources—identified natural gas resources have increased fourfold over the past 20 years and there is significant potential for further gas discoveries.

More than half of Australia's annual natural gas production is exported. Liquefied natural gas exports are expected to increase over the next five years, particularly once the Greater Gorgon gas fields project commences operations in 2014. These gas fields are Australia's largest and are estimated to contain 40 trillion cubic feet of natural gas, valued at $500 billion at current market prices.

Uranium

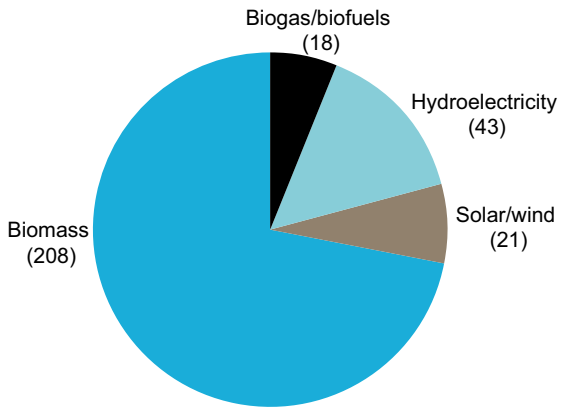
Australia has the world's largest economic demonstrated resource of uranium (1163 kt U) and,

after Canada, is the world's second largest producer, with approximately one-fifth of world uranium production. Australia has no significant national demand for uranium and all production is exported under stringent conditions to ensure it is used only for peaceful purposes.

2.3.2 Renewable energy

Australia's production of renewable energy is currently dominated by hydroelectricity and biomass, with wind, solar and biofuels accounting for the remainder (see Figure 2.1). Hydroelectricity production has decreased significantly in recent years, reflecting continuing drought conditions. As the most arid inhabited continent in the world, Australia has little further large-scale hydroelectric generation potential.

***Figure 2.1** Quantities of Australian renewable energy production/consumption, 2007–08 (PJ)*



Source: ABARE 2009, *Energy Update 2009*.

Australia has significant non-hydro renewable energy potential and is investing in emerging renewable energy technologies. Significant investments have been made to develop geothermal energy and hot rock technology and explore these resources.

The Carbon Pollution Reduction Scheme and the 2020 Renewable Energy Target will improve the competitiveness of alternative, cleaner technologies by requiring emissions-intensive fossil fuels to compete with renewable technologies on a playing field that reflects the real cost of greenhouse gas emissions. Australian Treasury modelling projects that by 2050 Australia's renewable energy sector output will be 30 times larger than it is today, with the expanded Renewable Energy Target and the Carbon Pollution Reduction Scheme. (See Chapter 4 for details of these policies.)

2.3.3 Domestic energy consumption

Australian primary energy consumption is dominated by readily available, low-cost fossil fuels, predominantly petroleum and coal, with major consumers being the electricity generation, transport and manufacturing sectors. Reflecting its relatively high standard of living, Australia is the world's 20th largest primary energy consumer, ranking 16th on a per person basis (ABARE 2009b).

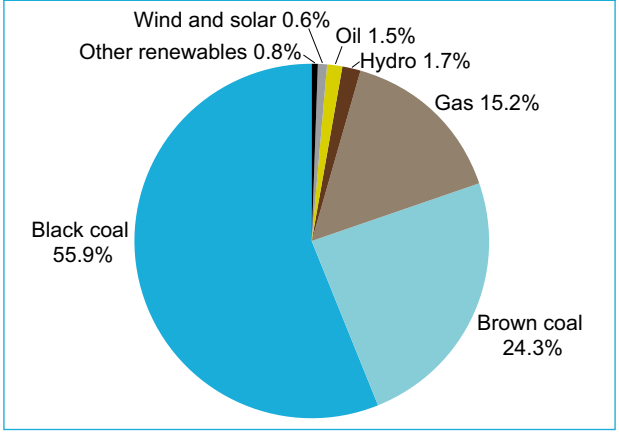
The electricity generation sector is the largest consumer of energy inputs and has historically been one of the fastest-growing sectors. Other major energy-using sectors are the transport and manufacturing sectors. Together these three sectors account for more than 75% of Australia's energy consumption. In terms of energy consumption these sectors were followed by the mining, residential and commercial services sectors.

Despite falling energy prices and robust economic growth, annual average growth in primary energy consumption has remained relatively low, around 2.3%, over the past 50 years.

2.3.4 Electricity

In 2007–08, total electricity production in Australia was around 925 petajoules. Coal-fired electricity generation is a significant component of domestic energy needs, comprising 80.2% of fuel used for electricity generation in 2007–08 (see Figure 2.2). Black coal is expected to remain the most commonly used fuel in electricity generation. It is, however, expected that an increasing proportion of electricity generation projects will use natural gas, coal-seam methane and renewables.

***Figure 2.2** Fuel inputs to Australian electricity generation, 2007–08*



Source: ABARE 2009, *Australian Energy Statistics*.

2.3.5 Energy market structure

The Australian, state and territory governments regulate exploration, development, safety, environmental assessment and royalties in their respective jurisdictions. Commercial exploration and development of oil and gas is undertaken entirely by the private sector but is actively promoted through government-sponsored production and dissemination of basic geoscientific information.

The Australian energy market has been progressively reformed to create a national market for electricity and enhance the maturity of the gas industry. The national electricity market, comprising a wholesale sector and a competitive retail sector, is structured around a common pool, or spot market, for trading wholesale electricity. It provides an interconnected transmission network that allows for market-determined power flows across the participating eastern Australian states. All electricity produced by market generators must be traded through the central spot market. The Australian Energy Market Operator, established in July 2009, operates the electricity and gas markets throughout much of Australia, and is responsible for long-term national electricity transmission planning, and providing gas market information.

Some states and territories offer feed-in tariff schemes to promote solar energy where a premium rate is paid for electricity fed back into the electricity grid from a designated renewable electricity generation source like a rooftop solar system.

The Australian Government is currently developing a White Paper on Australian energy to set durable policy directions that will ensure Australia's future energy security.

2.3.6 Emissions intensity

The greenhouse gas emissions intensity of the Australian economy, expressed as emissions per dollar of GDP, has declined over the period 1990 to 2007 by 36.4%, from 0.9 to 0.6 kilograms CO_2 equivalent (CO_2-e) (DCC 2009). The falling trend in emissions per unit of GDP reflects specific emissions management actions across sectors, the large decline in land-use change emissions over the period and structural changes in the economy with stronger growth in the services sector than in the more energy-intensive manufacturing sector.

Overall, the effect of energy efficiency improvements across the economy has been a reduction in energy use below what it would otherwise have been of 0.4% a year over the past 17 years. This effect created energy savings in all sectors except the agriculture and mining sectors (ABARE, *End Use Energy Intensity in the Australian Economy*, 2009).

Direct CO_2-e emissions have increased in the following sectors: mining (77.3%, or 24.8 Mt); electricity, gas and water (51.1%, or 69.7 Mt); residential (24.8%, or 10.8 Mt); services, construction and transport (19.3%, or 9.4 Mt); and manufacturing (9.9%, or 6.5 Mt).

Agricultural emissions are a relatively more important emissions source for Australia than for most other OECD countries, contributing around 16% of national emissions. The agriculture sector is the dominant national source of both methane and nitrous oxide, which account for 67.9 Mt CO_2-e (58.9%) and 20.2 Mt CO_2-e (85.9%) respectively of the net national emissions for these two gases. Livestock-related emissions declined by 7.5% (4.9 Mt) between 1990 and 2007. This decline was principally driven by a 50.7% fall in sheep numbers, which was partially offset by a 13.9% rise in beef cattle numbers. The decline reflected the general decline in agricultural production for most of this decade due largely to severe drought conditions.

2.4 Industry

Australia's economic growth has historically been based on its abundant mineral, energy and agricultural commodities. While these sectors are still important, the services sector, including the banking, finance, tourism and retail sectors, is making an increasing contribution to growth in Australia's economy. This trend is apparent in the industrial profile of most other developed economies over recent decades.

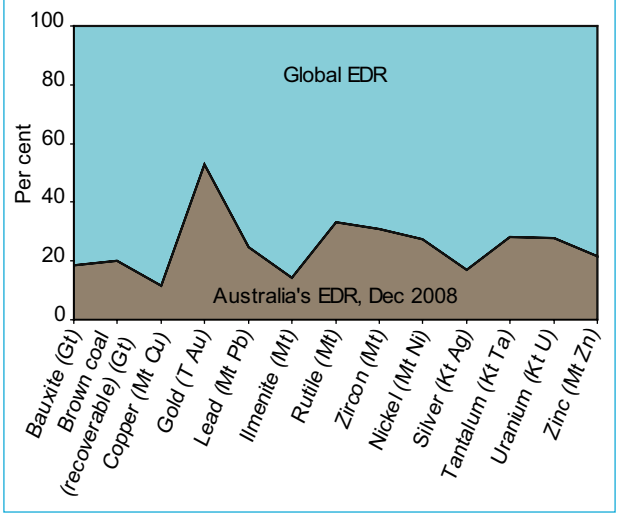
In 2008–09, the industry with the largest share of GDP (at basic prices excluding ownership of dwellings) was finance and insurance services with a share of 12%. Manufacturing was the second largest industry with a share of 10%. Mining's share of GDP was 8% in 2008–09, making it the third largest industry together with the construction industry.

Since late 2008, extractive, mining and mineral production and the agriculture sectors have experienced declining demand for exports. This slower economic growth as a result of the global financial crisis is projected to slow emissions growth over the Kyoto period by around 8 Mt CO_2. Australia would have been on track to meet its Kyoto target even without this lower economic growth.

Short profiles of key Australian industries follow. These industries are, for the most part, both energy- and emissions-intensive.

- Australia has some of the world's largest economic demonstrated resources of major minerals (see Figure 2.3) and continues to rank as one of the world's leading mining nations. The **mining industry** has increased as a share of GDP from 5% throughout the 1990s to 8% in 2008–09. The industry makes a significant contribution to Australian export earnings. Mining exports accounted for 41.5% (around $118 billion) of total exports in 2008–09, well above the 17.7% share in 1998–99. In the February 2009 quarter, 171 500 people were employed in the mining industry, the vast majority of whom work in remote and regional areas of Australia.
- Structurally, the **heavy engineering industry** is divided into several segments: iron and steel casting and forging, railway equipment, mining, steel fabrication, construction and agricultural machinery, and industrial machinery manufacturing. In 2008–09, the manufacturing of general machinery and equipment generated $11.7 billion in exports, while fabricated metal products generated $1.3 billion in exports. Machinery and equipment manufacturing had an industry value added of $19.9 billion, while metal product manufacturing had an industry value added of $25.7 billion. Employment in primary metal and metal products, fabricated metal products and machinery and equipment was around 265 000 in November 2009.
- The **automotive industry** is Australia's leading exporter of manufactured goods and one of the nation's top 10 export earners, surpassing traditional exports such as wheat, wool and wine. In 2008–09, the sector exported automotive goods valued at $4.5 billion, motor vehicles at $3 billion and automotive components at $1.5 billion. Major export markets for vehicles were Saudi Arabia, the United States and New Zealand, and major markets for components were the United States, South Korea and New Zealand. As at May 2009, there were 46 474 people employed in the automotive vehicle and part manufacturing sector, accounting for approximately 4.6% of total manufacturing employment.
- The **wood, pulp and paper industries** represent a large segment of Australian manufacturing and contribute to the economic and social wellbeing of rural and regional Australia. These industries encompass a range of sectors including timber harvesting and haulage, sawmilling, timber dressing, wood products, and pulp, paper and paper products manufacturing and timber merchandising. The Australian pulp and paper manufacturing sector generated $754 million in export earnings in 2008–09. The industry's turnover in Australia was $9.9 billion and industry value added was more than $2.9 billion.

Figure 2.3 Economic demonstrated resources (EDR) of major minerals, December 2008



2.5 Transport

Travel plays a large part in the national economy and in the everyday lives of most Australians. This is a consequence of the increasing affordability of travel and the demand for travel due to Australia's geographic size and dispersed population, as well as the distances between natural resources and manufacturing and market centres and the distances between Australia and its trading partners. Australia relies heavily on land transport networks (road and rail) to move freight and people in and between cities, and to major ports.

Australia's major population centres are located along the coastline, with long distances separating them. Significant amounts of freight are transported between these centres: by road, Brisbane is 982 km north of Sydney, which is 872 km by road from Melbourne. Adelaide is another 731 km from Melbourne; road transport from Adelaide to Perth requires a trip of approximately 2781 km, while Adelaide to Darwin is 3020 km. Hobart is separated from the other capitals by both distance and the waters of Bass Strait.

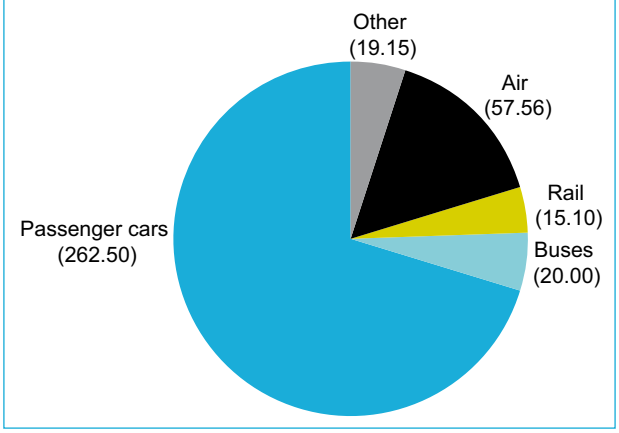
The transport sector is consequently the largest user of final energy, that is, energy in its final processed form, in Australia, with around 34% of final energy use employed in moving people and goods across the country. Road transport is the largest user of final energy in the transport sector, accounting for around three-quarters of the sector's fuel consumption. This is reflected in the significant consumption of liquid fuels (including LPG and refined products) by the transport sector, accounting for 72% of Australia's total use.

2.5.1 Passenger transport

Australian cities have comparatively low average urban population densities and are characterised by extensive suburban land-use patterns that result in significant distances between localities. As a consequence, the decentralised land-use patterns of Australian cities require greater intracity travel and reliance on private vehicle use. While public transport remains important in urban areas, private vehicles remain the principal mode of transport for the general public. The latest passenger task estimates for 2008–09 (in billion passenger kilometres) are presented in Figure 2.4. As at March 2009, passenger vehicles comprised 12 of the 16 million registered motor vehicles across Australia.

Petrol is the predominant fuel source, powering more than 88% of the Australian vehicle fleet. This is followed by diesel (9.3%) and LPG/dual fuel/other (2.5%). Around 95% of all registered passenger vehicles are powered by petrol, while nearly 86% of all rigid and articulated trucks are diesel powered.

Figure 2.4 Passenger task estimates for 2008–09 (in billion passenger kilometres)



Source: Unpublished BTRE estimates.

2.5.2 Domestic freight transport

Around two-thirds of domestic freight uplifted in Australia is hauled by road and 26% by rail. Road transport accounts for 80% of freight movements when the distance travelled is less than 100 km. A large proportion of rail freight involves intrastate movements of bulk commodities from their area of production to the seaport or processing location. Much of this is the long-haul movement of iron ore, oil and coal for secondary industry by coastal ships, and of primary products from inland mines and farms to coastal city markets and export ports by railway. Road transport remains important in the long-distance freight market on the north–south corridor linking cities along the eastern seaboard, whereas rail is more important in the east–west market of southern Australia.

2.6 Landscape and environment

Australia is endowed with an exceptional variety of landscapes. In the centre and west there are vast sandy deserts; in the east, sweeping plateaus and plains flank narrow coastal slopes. Australia has many unique and iconic landforms, ranging from the eroded volcanic rock of the Glasshouse Mountains on the north-east coast to the flat and expansive Nullarbor Plain in the south-west of the continent.

Australia has been geographically isolated from other continents for 35 million years, which has resulted in the evolution of a unique biota. More than one million different native species call Australia home. More than 80% of the country's flowering plants, mammals, reptiles and frogs are unique to Australia, along with most of its freshwater fish and almost half of its birds. Australia has more than 140 species of marsupials, including koalas and wombats. Australia also hosts the monotremes—egg-laying mammals—the most distinctive of which is the platypus, a river-dwelling animal with a duck-like bill, a furry body and webbed feet. This diversity has been internationally recognised and has led to Australia's classification as one of only 17 megadiverse countries.

Australia's unique natural heritage is preserved through its National Reserve System, which in 2008 included more than 9000 national parks and other protected areas, covering around 900 000 sq km, or more than 11% of Australia's land area. There are further protected areas on Australia's oceanic islands and external territories, as well as 200 marine protected areas. The vulnerability of Australia's natural ecosystems to the impacts of climate change is discussed in Chapter 6.

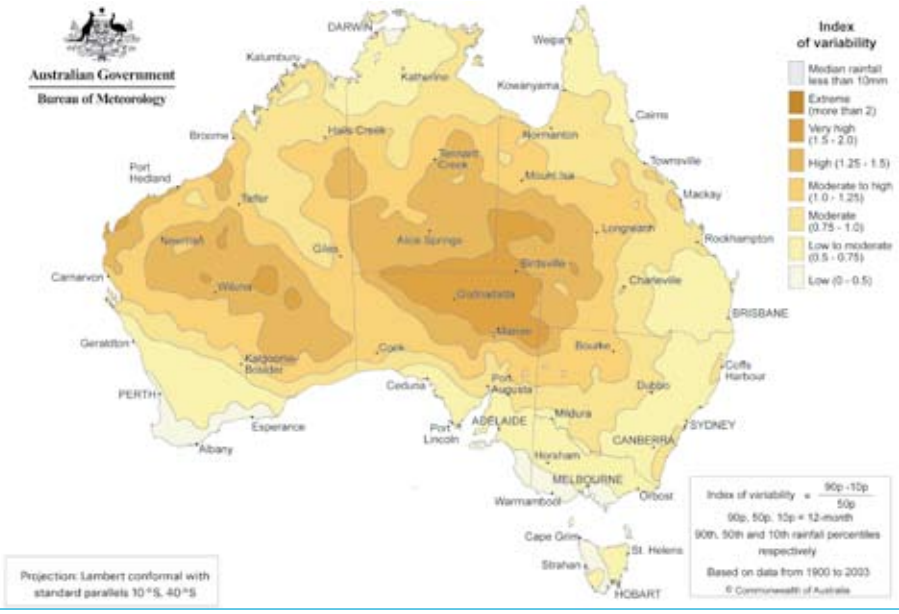
2.7 Climate

Australia is the driest of all inhabited continents. More than three-quarters of its land area has an average annual rainfall of less than 600 mm. Over half of the country receives less than 300 mm of rainfall annually. The uneven distribution of rain is highlighted in Figure 2.5, with high concentrations towards the coast and in mountain areas of north-eastern Queensland, south-eastern Australia and western Tasmania.

Rainfall in Australia is also subject to significant year-on-year variability (see Figure 2.6), which sets it apart from the majority of other countries listed in Annex I to the UNFCCC. Since 1950, most of eastern and south-eastern Australia has experienced substantial rainfall declines. In contrast, north-western Australia has seen a significant increase in annual rainfall, mostly during the summer months. Rainfall variability has been affected to a greater extent by the El Niño – Southern Oscillation phenomenon and the subtropical high pressure ridge. There were a record high number of El Niño events in the period 1977–2006, typically resulting in a reduction in winter and spring rainfalls across much of eastern, northern and southern Australia, and a corresponding record low number of rain-bearing La Niña events.

***Figure 2.5** Average annual rainfall distribution in Australia, 1961–90*

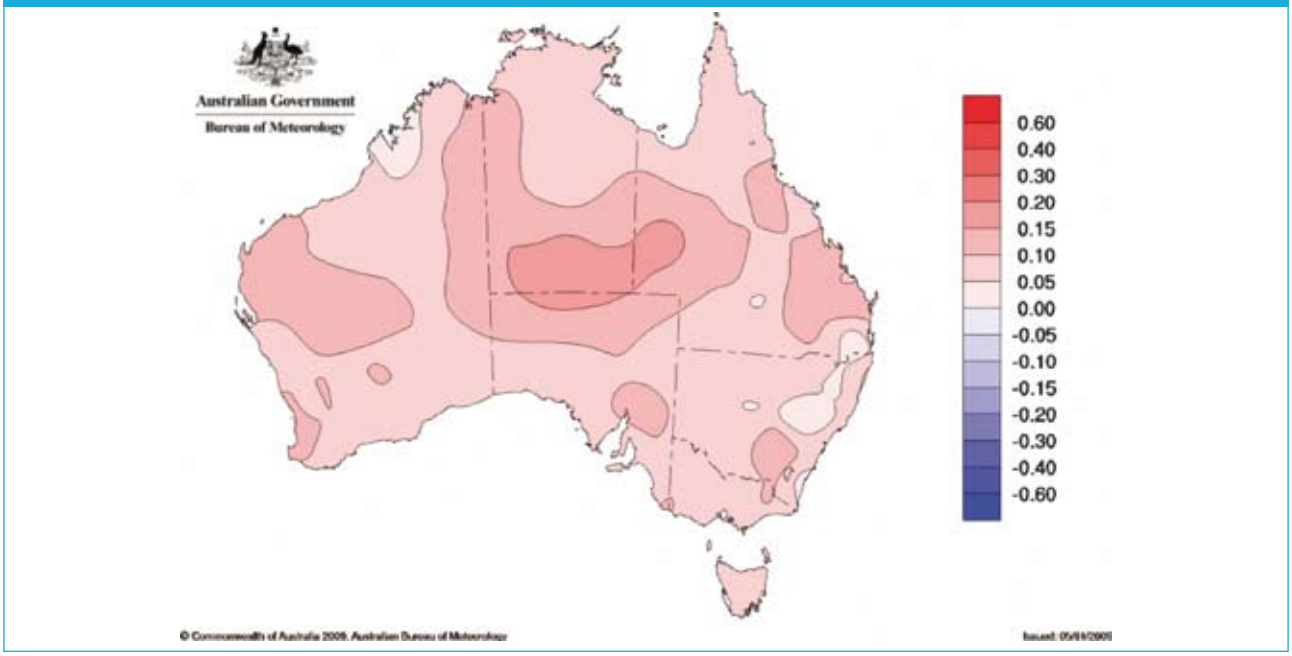
***Figure 2.6** Annual rainfall variability in Australia (percentile analysis relative to 30-year 1961–90 long-term average)*



The average annual temperature in Australia has increased by 0.9°C since 1910, with significant regional variations (see Figure 2.7). High temperatures over large areas of the continent, particularly in summer, have exacerbated the impact of the relatively frequent droughts, and impacted rainfall, evaporation and runoff and more generally water availability for human use. Temperature data show that 2009 was Australia's second warmest year on record and the decade (2000 to 2009) was Australia's warmest on record. In Australia, each decade since the 1940s has been warmer than the preceding decade. Trends in Australia's daily temperature are consistent with global warming. The last five to 10 years mark one of the most severe droughts in Australian history.

Snowfall in Australia is highly variable in area of coverage, depth and duration from year to year. It is usually restricted to south-eastern Australia at elevations above about 1500 metres. Maximum winter snow depths in the Snowy Mountains of south-eastern Australia have decreased slightly since 1962, and the snow depth in spring has declined strongly, by about 40%.

***Figure 2.7** Trends in annual mean Australian temperatures, 1910–2008 (° C/10 years)*



2.7.1 Climate change projections

The Commonwealth Scientific and Industrial Research Organisation and the Bureau of Meteorology have undertaken major work projecting Australia's future climate, which has been published as the *Climate Change in Australia: Technical report 2007*. Projections are given for 2030, 2050 and 2070 under a range of Special Report on Emissions Scenarios released in 2000 by the Intergovernmental Panel on Climate Change. For further information on the report, see Chapter 8.

By 2030, annual average temperatures could be between 0.4 and 0.8°C higher than those observed across most of Australia during the 20th century. Projected regional variations are likely to reflect the existing regional variations.

Unlike temperature, which is always projected to increase, climate models for future rainfall show greater uncertainty and considerable regional variation. Average annual rainfall is likely to decline in southern Australia and show little change in the far north. Simulations of future agricultural droughts, defined as changes in seasonal temperatures and/or the distribution or amount of rainfall that constrains agricultural production, show up to 20% more drought months over most of Australia by 2030. In many regions there may be increases in the intensity of extreme rainfall events, even if average annual rainfall declines.

2.8 Agriculture

Agriculture is the most extensive form of land use in Australia. In 2008, the estimated total area of farms in Australia was 417.2 million hectares, representing about 54% of Australia's total land area. Of this, livestock grazing accounts for the largest area of agricultural land use.

Australia's agricultural businesses encompass dairy farms and broadacre industries, which are those engaged in either grain growing (wheat and other crops such as cereal grains, coarse grains, pulses and oilseeds), sheep farming, beef cattle farming or a combination of two or more of these activities. The beef cattle farming industry was the largest sector, comprising around 33% of all agricultural businesses. Grain growers were the next largest sector at 11%, followed by the mixed farming sector (grain/sheep/beef cattle) at 10%. Farm businesses are located across Australia and form a vital part of rural communities and economies, including as major regional employers.

Australia's agricultural industries have utilised the large land area and developed a capacity to produce quantities substantially above requirements for the relatively small domestic population. Australian agriculture has subsequently become export oriented, with exports in recent years comprising some 60% of agricultural production. The reliance on exports varies among industries, with virtually all of Australia's wool and cotton, around three-quarters of Australia's wheat and sugar, two-thirds of its beef, almost two-thirds of wine production, half of sheep meat and about half of Australia's milk production being exported.

Australian agriculture is heavily influenced by seasonal conditions that can cause high volatility in productivity estimates. Since 2001–02, many agricultural regions of Australia have experienced higher-than-average temperatures and lower-than-average rainfall. The shift in climatic conditions has contributed to sharp falls in production and productivity in many agricultural industries. For example, historically low volumes of water allocations in recent years in the Murray–Darling Basin, a key irrigation region, have led to significant declines in the production of irrigated crops such as rice and cotton. Livestock production has also been affected by the severe drought. At 71.6 million head, sheep and lamb numbers in 2008 were at their lowest levels since 1905. Pig numbers continued their falls of recent years, with an estimated herd size of 2.2 million being the smallest reported since 1978.

The impact of the decline in agricultural production has significant flow-on effects for the economy, with a severe drought typically reducing GDP growth by one percentage point.

2.9 Forestry

Australia has 107 million hectares of forest. Of this, 105 million hectares are native forest and 2 million hectares are plantation. The total forest area reported here is significantly different from the total of 164 million hectares reported in the Fourth National Communication, due to differences in definitions and methodologies used to compile the data.

The earlier estimate was based on National Forest Inventory (NFI) data. Current estimates, however, were determined using Australia's National Carbon Accounting System, which uses satellite imagery to determine vegetation cover change for Australia's land use, land-use change and forestry reporting under the UNFCCC and Kyoto Protocol. The estimates reported here are consistent with Australia's initial report under the Kyoto Protocol and 2007 national inventory submission.

The forest definition adopted for both Australia's greenhouse gas inventories and the NFI incorporates a height of two metres and crown cover of 20%. Unlike the NFI, however, a minimum forest area of 0.2 hectares is adopted for emissions reporting.

Plantations now produce two-thirds of the country's log supply. This share is likely to increase due to the planned expansion of the plantation estate to three million hectares by 2020 and a long-term decline in the volume of timber harvested from native forests.

Predicted changes in climate could have profound effects on forests, forest production and the incidence and severity of fire, pests and disease. For example, in 2003 wildfires in Australia's southern region burned approximately 1.5 million hectares of forests. Major wildfires lead to soil erosion and affect water quality across forest tenures, and resulting natural regrowth contributes to reduced water yields in affected catchments for decades.

2.10 Building stock and urban structure

Over the last 60 years, Australian cities have been transformed from fairly tight-knit 'core-and-spoke' configurations, to sprawling suburban low-density configurations. The majority of Australians live in

separate houses rather than medium-density apartment blocks. In March 2008, more than three-quarters of all households (77%) occupied separate houses, down from 81% in 1994. The majority (52%) of these separate houses had three bedrooms while a further 37% had four or more bedrooms.

Since 1911, there has been a slow but steady increase in the size of Australian dwellings. The average size of new residential dwellings has increased by around one-third over the last two decades. This trend has been accompanied by a steady decline in the average number of persons per dwelling.

2.11 Waste

Australians generated approximately 43.8 million tonnes of solid waste or approximately 2080 kilograms of waste per person in 2006–07 (Environmental Protection and Heritage Council 2009). Of this amount, 29% came from municipal sources (domestic and other council waste), 33% from the commercial and industrial sector and 38% from the construction and demolition sector.

Australia has a strong dependence on landfill for waste management with around half (48%) of all solid waste, some 21 million tonnes, deposited in 2006–07. The remainder (52%), about 23 million tonnes, was recycled and reprocessed into a usable production input. In March 2009, 99% of Australian households participated in some form of recycling and/or reuse of waste (ABS 2009e).

Growth in the amount of waste generated per person reflects Australia's fast-growing, material-intensive economy and changes in population demographics. As noted above, Australians are tending to live in smaller household groups; this trend is associated with an increase in the ownership of more durable goods per person and in the consumption of smaller-serve goods that have higher packaging-to-product ratios.

Note, the first comprehensive national collation of waste data was published in 2006. The waste data presented above were published in 2009 in the National Waste Policy Overview and represent the most up-to-date national collation of waste data.

References and sources

Note: In preparing this chapter, the most recent published information was used. Inconsistencies in the years of the datasets reported are due to variations in the frequency of data collection, analysis and publication.

Items in **bold** either are cited in the text of the chapter or are sources for figures and tables. Australian government information online is easily accessible through www.australia.gov.au.

ABARE (Australian Bureau of Agricultural and Resource Economics) 2009a, *Australian Mineral Statistics 2009, September quarter 2009*, ABARE, Canberra.

——2009b, *Energy in Australia 2009*, ABARE, Canberra.

ABS (Australian Bureau of Statistics) 2007, *Australia's Environment: Issues and trends*, cat. no. 4613.0, ABS, Canberra.

——2008, *Environmental Issues: Energy Use and Conservation—Australia*, cat. no. 4602.0.55.001, ABS, Canberra, March.

—— 2008, *Housing Occupancy and Costs 2007–08*, cat. no. 4130.0, ABS, Canberra.

——2009a, *Australian Economic Indicators, Oct 2009*, cat. no. 1350.0, ABS, Canberra.

—— 2009b, *Australian Industry, 2007–08,* cat. no. 8155.0, ABS, Canberra.

——2009c, *Australian National Accounts: National Income, Expenditure and Product, September quarter 2009*, cat. no. 5206.0, ABS, Canberra.

——2009d, *Australian System of National Accounts, 2008–09*, cat. no. 5204.0, ABS, Canberra.

—— 2009e, *Environmental Issues: Waste Management and Transport Use*, cat. no. 4602.0.55.002, ABS, Canberra.

——2009f, *Labour Force, Australia, Detailed, Quarterly, Nov 2009*, cat. no. 6291.0.55.003, ABS, Canberra.

——2010, *International Trade in Goods and Services, Australia, Nov 2009*, cat. no. 5368.0, ABS, Canberra.

BITRE (Bureau of Infrastructure, Transport and Regional Economics, Department of Infrastructure, Transport, Regional Development and Local Government) 2009, *Australian Transport Statistics Yearbook 2009*, Canberra.

Bracks, S 2008, *Review of Australia's Automotive Industry*, Department of Innovation, Industry, Science and Research, Canberra.

CSIRO (Commonwealth Scientific and Industrial Research Organisation) and BoM (Bureau of Meteorology) 2007, *Climate Change in Australia: Technical report 2007*, CSIRO, Melbourne.

DCC (Department of Climate Change) 2008, *Tracking to the Kyoto Target 2007: Australia's greenhouse emissions trends 1990 to 2008–2012 and 2020*, DCC, Canberra.

—— 2009, *Australian National Greenhouse Accounts: National inventory by economic sector 2007*, DCC, Canberra.

Department of Agriculture, Fisheries and Forestry 2008, *Australia's State of the Forests Report 2008*, Canberra.

Department of Innovation, Industry, Science and Research 2008, *Key Automotive Statistics*, Canberra.

Department of Resources, Energy and Tourism 2009a, *Discussion Paper: Investment, competitive markets and structural reform*, Canberra.

—— 2009b, *Discussion Paper: Realising Australia's energy resource potential*, Canberra.

—— 2009c, *National Energy Policy—Framework 2030: Strategic directions paper*, Canberra.

Environmental Protection and Heritage Council 2009, *National Waste Overview 2009*, EPHC, Adelaide.

Garnaut, R 2008, *The Garnaut Climate Change Review: Final Report*, Cambridge University Press, Melbourne.

Geoscience Australia 2009, *Australia's Identified Mineral Resources* (AIMR) *2009,* Canberra.

Nicholls, N 2008, *Australian Climate and Weather Extremes: Past, present and future*.

Roberts, I, Haseltine, C & Maliyasena, A 2009. *Factors Affecting Australian Agricultural Exports*, ABARE, Canberra.

Schultz, A 2009, *Energy Update 2009*, ABARE, Canberra.

CHAPTER 3

National Greenhouse Gas Inventory

KEY DEVELOPMENTS

Since the Fourth National Communication Australia has:

- more accurate and comprehensive emissions estimates following adoption of new data, methods and source/sink categories
- introduced the *National Greenhouse and Energy Reporting Act 2007*, which establishes the legislative framework for a national greenhouse and energy measurement and reporting system for business to government
- improved the national inventory system through strengthening of the planning and quality control systems
- established the Australian National Registry of Emissions Units to meet its Kyoto Protocol reporting requirements.

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, Australia has an obligation to prepare, publish and update greenhouse gas inventories on an annual basis.

Australia's most recent inventory covers the year 2007 and was submitted to the UNFCCC Secretariat in 2009. In accordance with UNFCCC requirements, this chapter provides a summary of the inventory results for the period 1990 to 2007. Additional summary tables are included in Annex I. A complete report of greenhouse gas emissions and removals and their associated estimation methodologies can be found in Australia's *National Inventory Report 2007* (DCC 2009).

Under the Kyoto Protocol, Annex I Parties are required to have in place a national system for estimating greenhouse gas emissions and removals and for reporting and archiving inventory information. The national system ensures the quality of the inventory through planning, preparation and management of inventory activities. This chapter outlines the main components of Australia's national system.

In accordance with the reporting requirements for the Kyoto Protocol this chapter also includes a description of the structure and functions of the national registry (the Australian National Registry of Emissions Units).

3.1 Overview of national emissions

Australia's inventory provides a comprehensive inventory of human-induced greenhouse gas emissions and sinks from the following sectors and subsectors:

- energy (including stationary energy, transport and fugitive emissions from fuel)
- industrial processes
- solvent and other product use
- agriculture
- land use, land-use change and forestry
- waste.

The inventory covers the major greenhouse gases—carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). Also covered in ancillary fashion are the indirect greenhouse gases—carbon monoxide (CO), oxides of nitrogen (NO_X), and non-methane volatile organic compounds (NMVOCs). Sulphur dioxide (SO_2), an aerosol precursor, is also included because emissions of this gas influence global warming. The geographical

AUSTRALIA'S NATIONAL GREENHOUSE ACCOUNTS

The National Inventory Report is the cornerstone of the national greenhouse accounts. It enables Australia to meet its international reporting obligations and provides information at a sectoral level according to the classification system of the Intergovernmental Panel on Climate Change (IPCC).

The IPCC process-based classification was designed with ease of estimation and verification of national emissions in mind. Some stakeholders find the classification system does not meet their needs. Complementary classifications of emissions within the national inventory that better address the needs of users have been developed.

The national inventory is embedded within a set of national greenhouse accounts. These provide more information for users with respect to Australia's emissions on both a regional and industry basis. They also provide additional quality control for the inventory in terms of enhanced consistency, transparency and comparability.

In addition to the National Inventory Report the Australian national greenhouse accounts include:

- the National Greenhouse Gas Inventory, which provides an assessment of Australia's progress against the Kyoto Protocol target
- quarterly updates, which provide a preliminary estimate of emissions for the latest quarter
- an overview of the state and territory greenhouse gas inventories
- the National Inventory by Economic Sector, which comprises emissions estimates by economic sector (rather than by IPCC sectors, as in this report).

The national greenhouse accounts are available on the Department of Climate Change's website.

coverage of the Australian inventory includes the states and mainland territories, associated coastal islands, and external territories (Australian Antarctic Territory, Norfolk Island, Christmas Island, Cocos Islands, Heard and McDonald Islands, Coral Sea Islands and Ashmore and Cartier Islands).

The greenhouse gas emissions and removal reported in this chapter have been prepared in accordance with the accounting rules that apply for the UNFCCC. There are some major differences between the UNFCCC rules and the rules used for the Kyoto Protocol, most notably those for the land use, land-use change and forestry (LULUCF) sector.[1] This means that the emissions totals and trends for the purposes of the UNFCCC and the Kyoto Protocol are different.

3.1.1 Emissions profile

In 2007, Australia's total greenhouse gas emissions—excluding the LULUCF sector—were 541.2 million tonnes (Mt) CO_2 equivalent (CO_2-e) (see Table 3.1). Energy-related emissions (stationary energy, transport and fugitive emissions from fuels) dominate Australia's emissions profile, contributing 75.4% of total emissions in 2007 (see Figure 3.1). Emissions associated with the agriculture sector are also a significant component (16.3%) of the inventory. The emissions from the industrial processes and waste sectors are relatively minor.

When the LULUCF sector emissions and removals are included in the total, Australia's net greenhouse gas emissions in 2007 were 825.9 Mt CO_2-e.[2] From year to year the LULUCF sector may change from a net source to a net sink. In 2007, the LULUCF sector was a net source of 284.7 Mt CO_2-e.

3.1.2 Emissions trends

According to the accounting provisions of the UNFCCC, Australia's total greenhouse gas emissions (excluding the LULUCF sector) increased by 30% between 1990 and 2007. When the LULUCF sector emissions and removals are included, Australia's net greenhouse gas emissions in 2007 increased by 82% compared with 1990 levels.

Sectors with increasing emissions over the period 1990 to 2007 included stationary energy (up 49.5%),

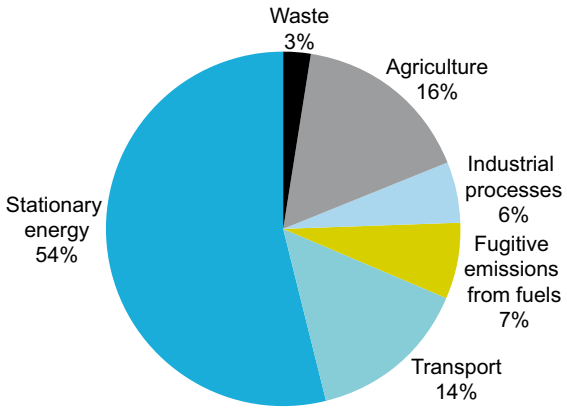
1 LULUCF emissions and removal under the Kyoto Protocol accounting framework are restricted to a subset of activities (i.e. afforestation, reforestation and deforestation) that have occurred since 1990.

2 This total does not reflect Australia's emissions and removals under the Kyoto Protocol.

***Table 3.1** Net greenhouse gas emissions (Mt CO_2-e) by sector in Australia, 1990, 2006 and 2007*

Sector	1990	2006	2007	Change 1990–2007 Mt CO_2-e	Change 1990–2007 %
Energy	286.4	400.1	408.2	121.7	42.5
Stationary energy	195.1	287.1	291.7	96.6	49.5
Transport	62.1	78.6	78.8	16.7	26.9
Fugitive emissions from fuels	29.2	34.3	37.7	8.4	28.9
Industrial processes	24.1	29.4	30.3	6.2	25.7
Agriculture	86.8	90.8	88.1	1.3	1.5
Waste	18.8	14.2	14.6	–4.2	–22.5
Total net emissions (excluding LULUCF)	**416.2**	**534.5**	**541.2**	**125.0**	**30.0**
Land use, land-use change and forestry	37.6	16.6	284.7	247.1	657.6
Total net emissions (including LULUCF)	**453.8**	**551.1**	**825.9**	**372.1**	**82.0**

***Figure 3.1** Contribution to total CO_2-equivalent emissions by sector in Australia, 2007 (excluding LULUCF)*



transport (up 26.9%), fugitive emissions from fuels (up 28.9%), industrial processes (up 25.7%), agriculture (up 1.5%) and LULUCF (up 657.6%). Waste decreased (down 22.5%).

The principal drivers of these emissions trends are as follows:

- **Energy**: The largest sectoral increase in greenhouse gas emissions over the period 1990 to 2007, of 49.5% (96.6 Mt CO_2-e), occurred in the stationary energy sector, driven in part by increasing population and household incomes and export increases from the resources sector. The main driver for the increase in transport emissions is continuing growth in household incomes and numbers of vehicles. Fugitive emissions have increased due to increased production from gassy underground coalmines.
- **Industrial processes**: The increase in emissions since 1990 is primarily driven by the growth in emissions associated with HFCs and the chemical industries.
- **Agriculture**: Between 1990 and 2001, emissions increased due to increased fertiliser use and savanna burning. Since 2002, southern and eastern Australia have experienced widespread drought conditions, which have contributed to reductions in animal populations, crop production, fertiliser use and associated emissions.
- **Waste**: The net emissions from waste have decreased as increases associated with growing populations and industrial production have been offset by increased methane recovery.
- **LULUCF**: The LULUCF sector changes between a net source and a net sink a number of times through the time series. The trends in the LULUCF sector are primarily driven by inter-annual climate variability and natural disturbance. The trend in net emissions in the early 1990s is driven by the reduction in forest conversion emissions; the shift from a net sink to net source in 1995, 1998 and 2002 and the large spike in 2007, however, are due to natural disturbances such as fires and severe drought conditions, which caused a loss of carbon from all pools.

3.2 Emissions by greenhouse gas type

In 2007 carbon dioxide had the largest share of the 825 Mt of greenhouse gases in Australia's inventory, at 81.7% (674.9 Mt) of total CO_2-e emissions, followed by methane, which comprised 14.5% (119.8 Mt CO_2-e). The remaining gases made up 3.8% (31.2 Mt CO_2-e) of Australia's greenhouse gas emissions (see Table 3.2).

3.2.1 Carbon dioxide

The majority of carbon dioxide emissions in Australia (Table 3.3) arise from the combustion of fossil fuels. Carbon dioxide emissions from energy-related sources totalled 372.1 Mt in 2007, of which stationary energy accounted for about 85.9% and transport around 14.0%. The largest single contributor to carbon dioxide emissions was electricity generation (which relies mainly on coal), followed by road transport.

Emissions of carbon dioxide (excluding the LULUCF sector) increased by 42.6% between 1990 and 2007. During this period, carbon dioxide emissions from the

***Figure 3.2** Trends in CO_2-e emissions and removals by sector in Australia, 1990 to 2007*

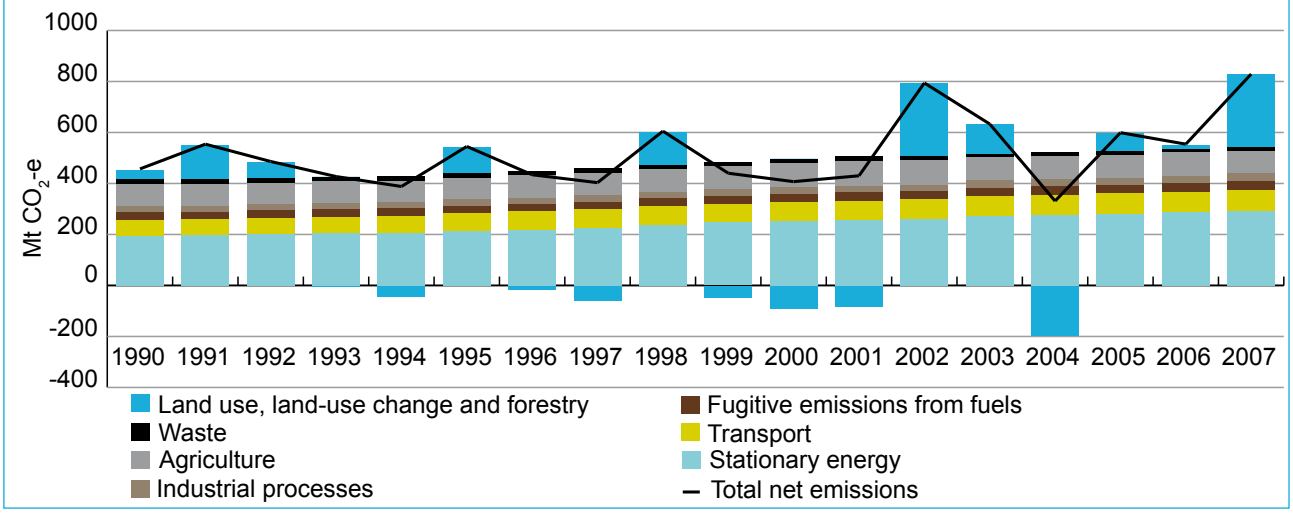


Table 3.2 ***Australia's net greenhouse gas emissions by gas, 1990 and 2007***

Greenhouse gas	1990		2007		Change
	Mt CO_2-e	% of total	Mt CO_2-e	% of total	Mt CO_2-e
Carbon dioxide (CO_2)	308.3	67.9	674.9	81.7	366.6
Methane (CH_4)	119.8	26.4	119.8	14.5	0.0
Nitrous oxide (N_2O)	20.1	4.4	25.0	3.0	4.9
Hydrofluorocarbons (HFCs)	1.1	0.3	5.1	0.6	4.0
Perfluorocarbons and sulphur hexafluoride (PFCs and SF_6)	4.5	1.0	1.0	0.1	– 3.4
Total CO_2-e emissions	**453.8**	**100.0**	**825.9**	**100.0**	**372.1**

Table 3.3 ***Total carbon dioxide emissions and removals (Mt) by sector in Australia, 1990 and 2007***

Sector	1990	2007	Change (Mt CO_2-e)	Change (%)
Energy	259.3	372.1	112.9	43.5
Stationary energy	192.6	289.5	96.9	50.3
Transport	60.7	76.5	15.7	25.9
Fugitive emissions from fuels	6.0	6.2	0.2	3.0
Industrial processes	18.5	24.1	5.7	30.7
Waste	0.07	0.03	0.0	–60.6
Total net emissions (excluding LULUCF)	**277.8**	**396.3**	**118.5**	**42.6**
Land use, land-use change and forestry	30.5	278.7	248.2	814.4
Total net emissions (including LULUCF)	**308.3**	**674.9**	**366.6**	**118.9**

energy sector increased by 43.5% while those in the industrial processes sector increased by 30.7%.

The LULUCF sector is another major source of carbon dioxide emissions. In 2007, net carbon dioxide emissions from LULUCF were 248.2 Mt, which represents a significant increase on 1990 levels. The trends in the LULUCF sector emissions are primarily driven by inter-annual climate variability and natural disturbance. The significant increase in net emissions in 2007 was caused by extensive drought conditions.

3.2.2 Methane

Australia's CH_4 emissions (Table 3.4) amounted to 5.7 Mt in 2007, equivalent to 119.8 Mt carbon dioxide. There has been little change since 1990.

The agriculture sector accounted for around 56.7% of national CH_4 emissions in 2007. Livestock contributed 87.4% of CH_4 emissions from this sector through enteric fermentation and the decomposition of animal wastes. Smaller quantities of CH_4 were generated through rice cultivation, burning of savannas and field burning of crop residues. Methane emissions from the agriculture sector declined by 4.0% between 1990 and 2007 due to a reduction in animal numbers and rice cultivation in response to reduced water availability in rice-growing regions.

Fugitive emissions from fuels accounted for about 26.3% of national CH_4 emissions. About 85.3% of these fugitive emissions came from the mining of coal for domestic use and export. Fugitive emissions from coal mining have increased by 65.3% between 1990 and 2007. Notably, emissions have not increased as fast as coal production as there has been a shift to the less methane-intensive open-cut mines and an increase in gas recovery.

Another significant contributor to CH_4 emissions is the waste sector, which accounted for 11.6% of the national total. Anaerobic decomposition of organic matter in landfills generated 79.6% of the CH_4 emissions from this sector. There was a 23.5% decrease in waste sector CH_4 emissions between 1990 and 2007—as rates of methane recovery from waste have improved significantly since 1990.

Table 3.4 ***Total CH_4 emissions (Mt CO_2-e) by sector in Australia, 1990 and 2007***

Sector	1990	2007	Change (Mt CO_2-e)	Change (%)
Energy	25.6	33.3	7.7	30.0
Stationary energy	1.8	1.3	–0.6	–31.5
Transport	0.6	0.6	0.0	–3.1
Fugitive emissions from fuels	23.2	31.5	8.3	35.7
Industrial processes	0.1	0.1	0.0	4.4
Agriculture	70.7	67.9	–2.8	–4.0
Land use, land-use change and forestry	5.1	4.5	–0.6	–12.1
Waste	18.2	13.9	–4.3	–23.5
Total emissions	**119.8**	**119.8**	**0.0**	**0.0**

Table 3.5 ***Total N_2O emissions (Mt CO_2-e) by sector in Australia, 1990 and 2007***

Sector	1990	2007	Change (Mt CO_2-e)	Change (%)
Energy	1.50	2.70	1.20	79.7
Stationary energy	0.72	0.98	0.25	35.1
Transport	0.75	1.70	0.96	128.1
Fugitive emissions from fuels	0.04	0.03	–0.01	–28.7
Industrial processes	0.02	0.02	0.00	–20.6
Agriculture	16.09	20.16	4.07	25.3
Land use, land-use change and forestry	2.01	1.57	–0.43	–21.6
Waste	0.49	0.59	0.10	20.1
Total emissions	**20.11**	**25.04**	**4.93**	**24.5**

3.2.3 Nitrous oxide

Australia's N_2O emissions (Table 3.5) were 0.1 Mt in 2007, equivalent to 25.0 Mt CO_2. This was 24.5% more than in 1990.

The agriculture sector accounted for 80.5% of national N_2O emissions. Most of this was produced from the application of fertiliser and animal wastes to agricultural soils. Burning of savannas, field burning of agricultural residues and manure management accounted for the balance. Nitrous oxide emissions in this sector increased by 25.3% between 1990 and 2007 due to increasing intensification of the livestock industries and increased application of fertilisers.

The transport subsector accounted for 6.8% of the N_2O inventory. Emissions of N_2O from transport more than doubled between 1990 and 2007 due to an increase in the number of vehicles using three-way catalytic converters.

3.2.4. Fluorinated greenhouse gases

Emissions of HFCs increased by 354% between 1990 and 2007. HCFC-22 was produced in Australia from 1990 to 1995 and by-product emissions of HFC-23 peaked at 1.4 Mt CO_2-e in 1993. The use of HFCs in Montreal Protocol industries commenced in 1994, and estimated emissions from this source have increased to 5.1 Mt.

Most emissions of PFCs in Australia are generated during aluminium production. Better management of the aluminium smelting process and a shift of production to smelters with lower PFC emissions rates resulted in emissions declining from about 4.0 Mt CO_2-e in 1990 to 0.5 Mt CO_2-e in 2007, a fall of about 87%, despite an increase in aluminium production of 59% (1.2 Mt of aluminium in 1990 to 2.0 Mt in 2007).

Emissions of SF_6 from the electricity supply industry are estimated at a constant level of 0.5 Mt CO_2-e. Between 1996 and 2000 a small quantity SF_6 was used as a cover gas in experimental work on magnesium casting.

3.2.5 Indirect greenhouse gases and SO_2

The indirect greenhouse gases (NO_x, CO, NMVOCs) and SO_2 are also reported in the inventory but as they have not been allocated global warming potentials they are not included within Australia's total aggregated emissions. Since 1990 there have been increases in the emissions of CO, NO_x, NMVOCs and SO_2 (Table 3.6).

Table 3.6 ***Total emissions (Mt CO_2-e) of indirect greenhouse gases and SO_2, 1990 and 2007***

Greenhouse gas	1990	2007	Change (%)
Oxides of nitrogen ($NO_{x)}$	1.8	2.6	42.7
Carbon monoxide (CO)	20.8	25.3	21.5
Non-methane volatile organic compounds (NMVOCs)	2.2	2.4	6.2
Sulphur dioxide ($SO_{2)}$	1.6	2.5	56.2

The main source of NO_x is the energy sector, with road transportation as the largest single source. The agriculture and LULUCF sectors are the largest producers of CO and NMVOCs. These gases, along with NO_x, are emitted during biomass burning. Emissions of SO_2 occur in the industrial processes and energy sectors. The principal sources are other metal production (67%) and electricity production (25%).

3.3 National inventory system

In accordance with Article 5, paragraph 1 of the Kyoto Protocol, Australia has put in place a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. This section sets out the main components of Australia's national system.

3.3.1 Name and contact information for the national entity

The responsibility for Australia's national inventory has been assigned to a single agency—the Department of Climate Change, within the Prime Minister's portfolio, under the Administrative Arrangements Orders of the Australian Government (25 January 2008).

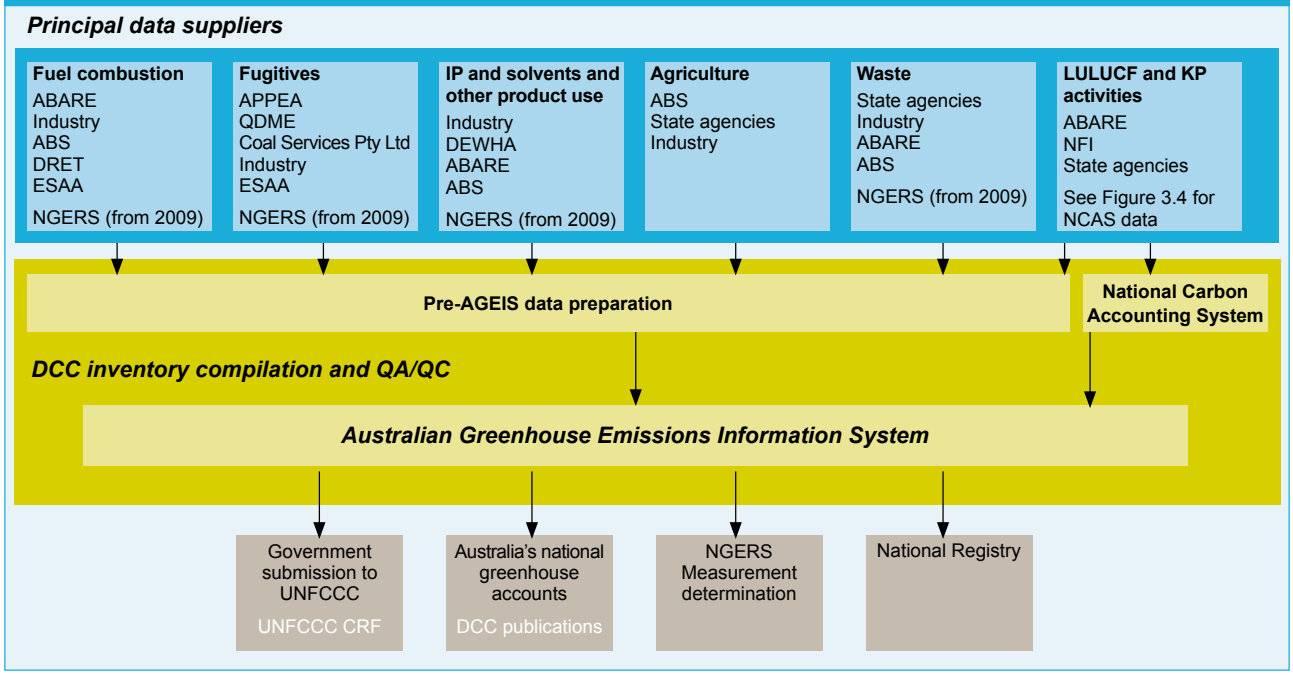
The designated representative with overall responsibility for the national inventory is:

The Director
National Inventory Team
Department of Climate Change
Australian Government
GPO Box 854
Canberra ACT 2601
AUSTRALIA
nationalgreenhouseaccounts@climatechange.gov.au

3.3.2 Roles and responsibilities

The Australian inventory is supported by a set of institutional arrangements that are designed to facilitate coordination of the inventory compilation, efficient emissions data management, broadly based quality assurance processes and secure, reliable data collections.

Figure 3.3 Department of Climate Change inventory asset structures and relationships



The Department of Climate Change within the Australian Government is responsible for all aspects of activity data coordination, emissions estimation, quality control, improvement planning, and preparation of reports and their submission to the UNFCCC on behalf of the Australian Government.

The department estimates emissions using the Australian Greenhouse Emissions Information System (AGEIS) and, for the LULUCF sector, the National Carbon Accounting System (NCAS) (see Figure 3.3). AGEIS centralises emissions estimation, inventory compilation, reporting and data storage processes into a single system. It has been used to consolidate Australia's emissions estimation methodologies and fully integrated quality control procedures into the compilation process. AGEIS provides high transparency levels for the inventory, with emissions data from the AGEIS database for the set of national inventory accounts publicly accessible through a dynamic web interface on the department's website.

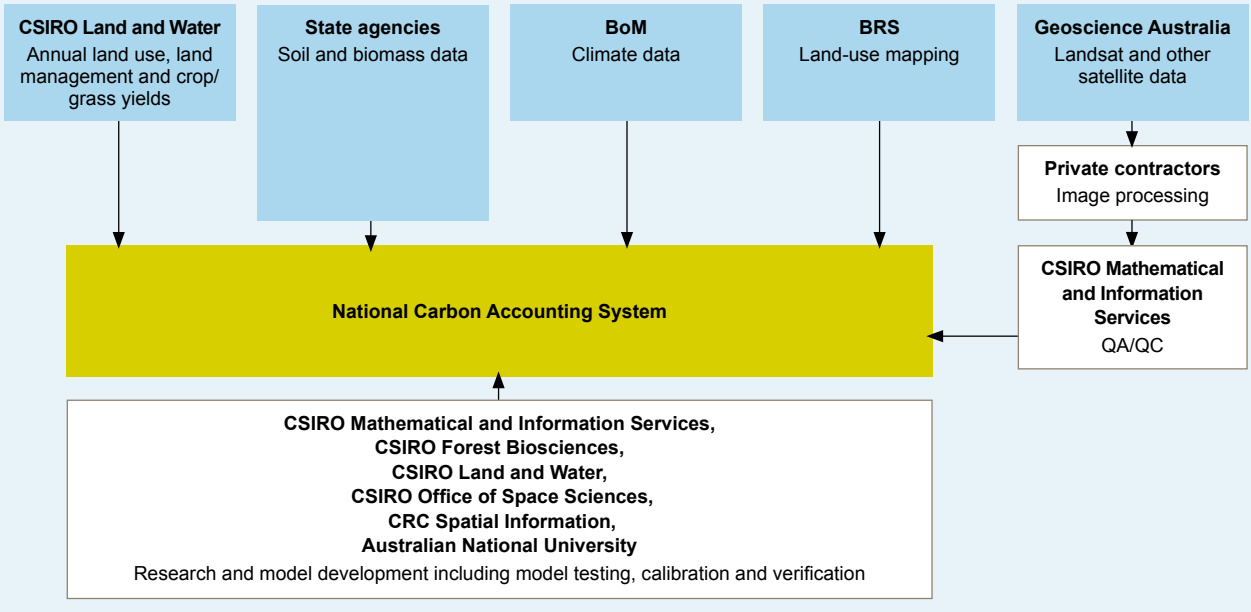
Department of Climate Change staff and external consultants have extensive experience in inventory preparation. The department aims to maximise the number of staff that have undergone the UNFCCC reviewer training and participated in UNFCCC expert review processes. All senior staff are qualified reviewers and have been accepted onto the UNFCCC Roster of Experts. The Australian Government has strongly supported the participation of Australian experts in the UNFCCC review process as this experience helps identify areas for improvement in Australia's inventory preparation.

Where particular technical expertise is not available within the department, consultants are engaged—selected from a pool of 16 experts—to undertake inventory preparation and review tasks. The pool is designed to foster a broad base of understanding of Australia's inventory systems and also to ensure that the department meets the competition principles of the Australian Government's procurement guidelines.

In the land use, land-use change and forestry sector, contributors to the inventory process include the Commonwealth Scientific and Industrial Research Organisation (CSIRO); the Cooperative Research Centre for Spatial Information, universities, state government research organisations and private sector providers. These contributors fulfil various roles, from data generation to quality assurance and validation (see Figure 3.4).

The Department of Climate Change primarily uses activity data published by Australia's principal economic statistics agencies, the Australian Bureau of Statistics (ABS) and the Australian Bureau of Agricultural and Resource Economics (ABARE). ABS is the national statistical agency, with legislative backing for its collection powers, and is the source of agricultural activity and some commodity and energy-related data. Data on energy consumption are sourced from ABARE, which publishes data from a survey of energy use that has operated for 30 years.

***Figure 3.4** National Carbon Accounting System institutional arrangements*



These data are also used to fulfil Australia's reporting requirements to the International Energy Agency.

The Department of Climate Change has instituted an annual cycle of evaluation through the preparation of an evaluation of outcomes document, providing a process for quality assurance and feedback for improvement to the national greenhouse accounts.

3.3.3 Process for official consideration and approval of the inventory

Preparation of the National Inventory Report is overseen by the Department of Climate Change's National Inventory Systems Executive Committee. The draft report is considered by the National Greenhouse Gas Inventory Committee, which comprises representatives of the Australian, state and territory governments and has been in place since the early 1990s. The committee is the principal mechanism for formal review of the report prior to its release. The National Inventory Report is also circulated before submission to other Australian government departments and agencies and relevant state experts through the National Greenhouse Gas Inventory Committee.

Release of each year's new inventory and submission to the UNFCCC is approved by the Australian Government Minister for Climate Change and Water.

3.3.4 Process for data collection, estimating emissions and archiving

Data collection

Data collection to support the preparation of Australia's inventory is managed centrally by the Department of Climate Change, which uses a mix of approaches to ensure the reliable flow of data from other agencies to support inventory preparation.

The data collection process is well integrated with the objectives of other programs, with a strong reliance on data collected and published by ABS and ABARE. Table 3.7 lists the principal data sources for the estimation of Australia's inventory.

The department employs consultants to collect data directly from companies for the industrial processes sector and to process the satellite imagery to determine land cover change for the LULUCF sector. Satellite imagery is sourced from Geoscience Australia (Australia's principal satellite ground station and data processing facility) via a memorandum of understanding. Data to support estimates of HFCs are sourced from compulsory reporting by importers under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 2003*. The collection of solid waste data from state and territory government agencies is supported by an exchange of letters.

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes the legislative framework for a national greenhouse and energy reporting system.

The reporting system established by the Act will underpin the introduction of a future Australian

Table 3.7 Principal data sources for the estimation of Australia's inventory

Category (UNFCCC sector)	Principal data sources	Principal collection mechanism
Energy sector (1A1, 1A2, 1A4, 1A5)	Australian Bureau of Agricultural and Resource Economics (ABARE), DCC collections	Published
Energy sector (1A3)	ABARE, Australian Bureau of Statistics	Published
Energy sector (1B)	Coal Services Pty Ltd, Australian Petroleum Exploration Association	Published
Industrial processes (2) and solvents (3)	DCC collection Australian Government Department of the Environment, Water, Heritage and the Arts	DCC survey Mandatory reporting of HFCs under import licensing arrangements
Agriculture (4)	Australian Bureau of Statistics	Published
Land use, land-use change and forestry (5)	Geoscience Australia ABARE	Memorandum of understanding Published
Waste (6)	State and territory government waste agencies	Exchange of letters between government agencies

Carbon Pollution Reduction Scheme (the scheme), and inform government policy and the Australian public. The NGER Act provides for a reporting system that will ensure:

- there is robust and transparent emissions reporting for the scheme
- there is a single streamlined national reporting point for greenhouse gas emissions and energy data to assist Commonwealth, state and territory government programs and activities
- Australia's international reporting obligations are met.

The Act makes reporting mandatory for companies whose energy production, energy use, or greenhouse gas emissions (from the energy, industrial processes and waste sectors) meet certain thresholds. The first reports were submitted to the Australian Government in October 2009 and covered the 2008–09 financial year. The data collected includes activity, emission factor and emissions data.

The Department of Climate Change has designed the regulations under the Act to ensure that the estimation methodologies used for company and facility emissions are estimated within the national greenhouse accounts framework, ensuring consistency among the relevant accounts—that is, national, state and territory, industry, company and facility-level inventories. Integration of the estimation methods and data is critical for ensuring that changes in emissions at facility level are captured efficiently and accurately in the national inventory. The default methods are the national inventory methods; the default emission factors have been derived using AGEIS and are set out in the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

Audit provisions and penalties for non-compliance are set out in the NGER Act. The Act, its regulations, and detailed regulations governing the audit system are on the department's website.

Estimation methodology

The Australian methodology for estimating greenhouse gas emissions and sinks uses a combination of country-specific and IPCC methodologies and emission factors. These methods are consistent with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 1997), the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC 2000) and *Good Practice Guidance for Land Use, Land Use Change and Forestry* (IPCC 2003) and accord with international practice.

The full description of the methods used by Australia in the estimation of emissions is provided in the *National Inventory Report 2007* (DCC 2009). In general, Australia's national greenhouse accounts have been moving towards a mix of tier 2 and tier 3 estimation methods that incorporate:

TRANSITION TO NATIONAL GREENHOUSE AND ENERGY REPORTING SYSTEM DATA

The arrangements for the collection of input data to support the preparation of the national greenhouse accounts for the energy, industrial processes and waste sectors are changing. From 2009 the National Greenhouse and Energy Reporting System (NGERS) will become the principal source of collections of activity data for the consumption of fuels, carbonates and wastes.

NGERS data sources will, where possible, replace the existing mix of Department of Climate Change collections and published data for the energy, industrial processes and waste sectors and will be supplemented by the use of published data sources from ABARE and Department of Climate Change collections only where necessary.

The data collected under the NGERS will be most valuable in cases where there is virtually complete coverage for a particular industry—for example, electricity generation. For other industries there will always be a residual of fuel consumption that will not be covered by the NGERS because of the presence of small consumers whose consumption levels do not breach reporting thresholds. Consequently, the accounts will continue to rely on existing published data sources to determine these residual fuel consumption amounts. In particular, ABARE Energy Balance data will be needed to supplement NGERS data for the finalisation of the accounts each year.

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

The additional complexity in the methodology allows emissions to be estimated more accurately.

The commencement of data collection under the NGER Act provides the foundation for a progression of national inventory estimation approaches towards tier 3 or plant-specific estimation approaches.

Tier 3 approaches are already in place for fuel combustion in the electricity industry and from fugitive emissions from underground coal mining sources. In future these existing tier 3 approaches will be supported by the use of the new NGERS data. For a range of additional sectors a mix of tier 2 and tier 3 approaches will be implemented over time. These sectors include the industrial products sector (mineral products, chemical products and metal products); the waste sector, particularly for solid waste disposal and waste water; and the fugitive emissions sector (from open-cut coalmines and oil and gas).

Emissions estimation

The Department of Climate Change introduced the Australian Greenhouse Emissions Information System (AGEIS) into the inventory production process in 2005. The system is designed to receive input and activity data; generate emissions estimates; facilitate quality control checks; and provide secure access by the public to the emissions database. The system is integrated with the UNFCCC Common Reporting Format Reporter Tool, which enables the smooth transfer of emissions data to the UNFCCC with the aim of improving the timeliness and quality of Australia's inventory submissions.

While the AGEIS is used for final preparation of the national greenhouse accounts, the National Carbon Accounting System (NCAS) plays a critical role in delivering the emissions and removal estimates for the LULUCF sector. Since 1998 the NCAS has been progressively developed to provide a complete greenhouse gas accounting capability for agriculture, forestry and land-use change (including all carbon pools, gases, lands and land-use activities). The eventual capacity will be a full spatial enumeration with emissions and removals calculated using a process-based, mass–balance carbon and nitrogen cycling ecosystem model. The progressive development of the NCAS is set around priorities according to the scale of emissions from either the land-use activity or carbon pool. To date the spatially explicit modelling capability of the NCAS has been completed for the conversion of forests to other land uses (for example, cropping and grazing) and for croplands.

Archiving

The Australian documentation systems aim to both manage and retain all data used in the estimation of emissions to ensure the continuity and security of the national inventory systems.

The AGEIS is at the heart of Australia's documentation systems as it allows efficient electronic data management and archiving of the significant quantities of data needed to generate an emissions inventory. Its data management functions include:

- archival and storage of the emissions estimates of past submissions
- archival and storage of past activity data, emission factors and other parameters and models
- archival and storage of data source descriptions, methodology descriptions and source reference material
- integrated access to the documentation of data sources, methodology descriptions and source reference material.

The aims of all these systems include giving inventory staff ready access to all relevant materials that underpin the emissions estimates and to provide the means for replication of emissions estimates from past submissions.

AGEIS functions are supported by some additional and important elements of the documentation system:

- documentation of the inventory's emissions estimation methodologies in the National Inventory Report
- maintenance of a national inventory library of source material documents.

3.3.5 Key category identification

Parties to the UNFCCC are required to identify key categories to ensure use of the appropriate methods and to prioritise inventory development and research efforts. A key category has a significant influence on

a country's total inventory of direct greenhouse gases in terms of absolute level of emissions, the trend in emissions, or both.

Australia has identified the key categories for the inventory using the tier 1 level and trend assessments as recommended in the IPCC *Good Practice Guidance for LULUCF* (2003). This approach identifies sources that contribute to 95% of the total emissions or 95% of the trend of the inventory in absolute terms.

When the LULUCF sector is included in the analysis, Australia has identified grassland remaining grassland, public electricity (solid fuel) and forest conversion to grassland as the most significant of the key categories (that is, contributing more than 10% of the level or trend) in 2007. When the LULUCF sector is excluded from the analysis the most significant key categories in 2007 are public electricity (solid fuel), road transportation and enteric fermentation (sheep). The full analysis of the key categories is available in Australia's *National Inventory Report 2007* (DCC 2009).

3.3.6 Recalculation of previously submitted inventory data

Inventory estimates are periodically recalculated. This occurs for a number of reasons, including end-of-series averaging effects (for the agriculture sector), and revisions to data due to refinements in the estimation methodology or the inclusion of additional sources. To ensure the accuracy of the estimates, and to maintain consistency of the series through time, recalculations of past emissions estimates are undertaken for all previous years. These recalculations are conducted in accordance with IPCC guidelines and are reported in Australia's national inventory reports.

The scope of planned future refinements of the Australian inventory is set out in the Inventory Improvement Plan. It is informed by the ongoing technical review of sectoral methodologies and data sources undertaken by the Department of Climate Change as part of Australia's efforts to comply with inventory good practice.

Priorities for the inventory development process are informed by:

- the need to reduce uncertainty of the national emissions estimates
- responses to international reviews
- changing international practice and changing IPCC methodologies
- the need to continue to review completeness of the inventory and to identify and estimate minor additional sources.

3.3.7 Quality assurance and quality control

Quality assurance and quality control processes for Australia's national inventory systems are outlined in full in the National Inventory Systems: Quality Assurance—Quality Control Plan 2009–10. The plan has been prepared to conform with good practice (IPCC 2000, 2003) and to contribute to the production of accurate inventories in which uncertainties are reduced to the extent practicable and which are transparent, documented, consistent over time, complete and internationally comparable.

To this end, the Department of Climate Change has established quality objectives for the national greenhouse account emissions estimates and for the National Inventory Report itself. The quality indicators comprise a mix of self-assessment and external assessment (in particular, by external consultants, the National Greenhouse Gas Inventory Committee and the UNFCCC expert review teams).

Quality control procedures

The key elements of the Department of Climate Change quality control procedures include:

- establishment of explicitly defined quality objectives for the national greenhouse accounts together with annual evaluations of the inventory against these objectives
- automated and systematised quality control processes built within AGEIS for all data handling and emissions estimation procedures, principally aimed at ensuring time series consistency and accuracy
- prioritisation of quality control processes built within AGEIS to ensure effort is principally directed toward key categories
- separation of data handling and data approval roles within the Department of Climate Change to improve accountability
- auditability of quality control tools to improve accountability
- reconciliation checks for emissions data with reference to Australia's national greenhouse accounts structure—national emissions estimates

are reconciled with the aggregation of state and territory emissions estimates; and IPCC emissions estimates are reconciled with economic sector classification estimates

- reconciliation checks for emissions data to ensure completeness of activity data for fossil fuels, biomass, carbonates and synthetic gases.

Tier 1 quality control checks

AGEIS plays a key role in facilitating the quality control of the national inventory. Key tier 1 quality control procedures for the inventory compilation process have been systematically built into the operation of AGEIS. Standardised and auditable checks are undertaken, for example, to reduce the risks of errors associated with the input of activity data, missing data, recalculations, and the time series consistency of generated emissions estimates. Tier 1 checks are also implemented during the pre-processing of input data.

Extensive internal verification of emissions estimates as well as external acceptance testing of system integrity and functionality was undertaken during the development of AGEIS. Emissions estimated by AGEIS were compared with those previously reported using traditional spreadsheets to ensure that:

- emissions were calculated correctly
- parameter and emissions units were correctly recorded
- data were correctly aggregated from lower to higher reporting levels.

Implementation of new estimation methodologies are undertaken using a dual estimation approach, which ensures that AGEIS emissions estimates are verified independently.

Mass–balance checks have been undertaken for all years to assess completeness and accuracy. All carbon entering the economy in fuels is accounted for—either as emissions from fuel combustion, emissions from the use of fossil fuels as reductants, non-energy uses, use of biomass sources of energy or international bunkers. Carbon balances for biomass and carbonates consumption and mass balances for synthetic gases are also being constructed.

Input data and implied emission factors are checked for time series consistency before submission using AGEIS software.

Tier 2 quality control checks

Category-specific quality control (tier 2) checks, such as comparison of activity data and implied emissions factors with those of other Annex I Parties and IPCC defaults, are also conducted. These checks are described in detail in the National Inventory Report.

National-level energy activity data are produced by ABARE through its annual Fuel and Electricity Survey. The ABARE data was reviewed and benchmarked by ABS in its role of national statistics coordinator in 2004 (ABS 2004). With respect to electricity, explicit reconciliations of energy data are undertaken by external consultants comparing data collected through Australian Government programs and supplemented by survey and the estimates produced by ABARE, the Energy Supply Association of Australia and the National Electricity Market Management Company—which are all undertaken for slightly different reasons and with slight differences in coverage.

Looking to the future, a key element of the quality control system will be the implementation of processes to assure the time series consistency of NGERS data before its application to the national greenhouse accounts. Initial analysis will be conducted by the Validation Unit of the Australian Climate Change Regulatory Authority. Additional analysis and evaluations of the population of available data will be conducted by the Department of Climate Change using standardised statistical techniques informed by international practice. A number of European Union parties have already incorporated data from the EU emissions trading scheme into their national inventories and this experience provides useful precedents for the evaluation of the time series consistency of the NGERs data.

Quality assurance procedures

Australia's quality assurance systems use a mix of approaches which, when taken together, provide a powerful structure of incentives for maintaining and enhancing the overall quality of the inventory. These quality assurance actions are principally undertaken by individuals not involved in the preparation of the inventory. Routine quality assurance processes include the following.

1. The national greenhouse inventory is reviewed each year by the National Greenhouse Gas Inventory Committee and by Australian government departments prior to its release.

2. Reconciliation of estimates with those of the Department of Climate Change are routinely performed by external consultants for specified sectors—electricity, mineral, chemical and metal products within industrial processes and agricultural soils within agriculture. Additional reconciliations have also been performed by international experts in, for example, the industrial processes sector.
3. Expert consultants that are not involved in the inventory preparation process regularly perform specific reviews of sectoral methodologies. For example, in 2008–09 external consultants were contracted to review the waste sector and, in 2009–10, reviews of specific waste sector parameters were conducted.
4. A wide range of quality assurance processes have been employed for the National Carbon Accounting System.
5. The transparency of inventory emissions estimates and methods published by the Department of Climate Change ensures that the inventory is open to public review each year. Industry and public feedback is encouraged through an email facility to the inventory contact point nationalgreenhouseaccounts@climatechange.gov.au.
6. UNFCCC expert review team processes aim to review and improve the quality of all Annex I inventories in an open and facilitative manner on an annual basis. Australia's inventory was reviewed by in-country teams in 2002, 2005 and 2008, with centralised reviews in other years.

Originally, expert working groups developed the Australian emissions estimation methodologies. An important quality assurance function is the ongoing review of estimation methodologies used to compile the Australian inventory undertaken in accordance with the Department of Climate Change Inventory Improvement Plan. This work focuses on key source categories—sectors where emissions have relatively higher uncertainties attached to them, and where the payoffs in terms of reduced uncertainty for the inventory overall might be expected to be greatest.

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 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 Australian National Registry was initialised with the International Transaction Log—an international system that links registries from different countries—on 19 December 2008. This system is managed by the UNFCCC Secretariat. It verifies the validity of transactions of Kyoto units including issuing, transfer, and acquisition between registries.

Formal notification for Australia to issue 2 957 579 143 assigned amount units (AAUs) was received from the International Transaction Log on 14 July 2009. Australia's AAUs were issued into the registry under instruction from the Minister for Climate Change and Water, the Hon. Senator Penny Wong, on 28 July 2009.

Organisations or individuals that wish to hold Kyoto units in Australia are required to have an ANREU account. The Australian Government will authorise legal entities to transfer and acquire Kyoto units using the Australian National Registry. Each entity will be required to comply with the applicable provisions of the Kyoto Protocol and the decisions of the parties to the Protocol, including the decision 'Modalities, rules and guidelines for emissions trading under Article 17 of the Kyoto Protocol'. This decision, along with the decision 'Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol' provides the basis for the rules that underpin the operation of the Australian National Registry.

The above decisions of the Kyoto Protocol require Australia to maintain a list of entities authorised by the Government to participate in international emissions trading and make that list available through the Australian National Registry. Australia is also required to make certain information publicly available, and to provide a publicly accessible user interface through the Internet that allows people to query and view the information.

Publicly available information will include the following:

- holder of each account
- type of each account (holding, cancellation or retirement)
- commitment period with which a cancellation or retirement account is associated
- representatives of account holders

- full name, mailing address, phone number, and email address of each account holder representative.

Name and contact information for the Australian National Registry:

Shaun Calvert
Registry Administrator
Emissions Trading Division
Department of Climate Change
GPO Box 854
Canberra ACT 2601
Tel: +61 2 6275 9689
Email: shaun.calvert@climatechange.gov.au

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

3.4.1 Database structure and capacity of the Australian National Registry

The following is an extract from the software specifications for the Australian National Registry.

SQL server database

The Australian National Registry of Emissions Units (ANREU) database is a Microsoft SQL Server 2005 database. The vast majority of the system's business logic is contained in stored procedures, views, and functions contained in the database instance. The ANREU has a complex system of metadata used to control many aspects of the system's configuration. Much of this metadata can be managed through the Registry Management Application (RMA) tool, from a desktop with network access to the database hosting environment.

SQL Server 2005 Reporting Services

SQL Server 2005 Reporting Services (SSRS) runs on the IIS web server (described below) and is configured with data sources that point to the ANREU SQL Server 2005 database. SSRS provides reporting functionality to the ANREU web application. The report content for the web application reports is controlled through metadata, which is managed through the RMA tool, from a desktop with network access to the database hosting environment.

In addition to the ANREU web application reports, SSRS hosts two administrative reports that are available through the RMA. These are the CPR Level report and the Kyoto report for submission to the UN. The CPR Level report allows the Registry Administrator to see the status of the registry with respect to the required commitment period reserve.

The commitment period reserve is the minimum quantity of Kyoto units that the registry must hold at any given time in order to limit the scope of non-compliance. The Kyoto report provides automatic generation of the required annual reports for Kyoto parties (COP 10). The report is generated using the standard electronic format (SEF) of submission under Article 7.1 of the Kyoto Protocol. SSRS also provides an ad hoc reporting capability intended for administrators that is accessible through the RMA tool.

IIS web server

The ANREU is primarily accessed through a web application. The web server used is Microsoft IIS, which communicates with the ColdFusion 8 application server.

ColdFusion MX 8 application server

The ANREU web application is developed in ColdFusion 8. The files comprising the ANREU ColdFusion application are distributed as a file tree. The ColdFusion application server runs as a service on the designated machine also hosting the IIS web server.

Hardware specifications

The ANREU application will be deployed to the web-hosting environment provided by AussieHQ. It is expected that each instance (production, standby, dev/test, etc.) of the ANREU application will be deployed in a clustered Microsoft SQL 2005 environment where each node meets the Microsoft recommended specifications of a 1 GHz Pentium III–compatible processor or higher and 1 GB or more of RAM. If deployed in an Active/Active cluster each node must be able to provide full failover of another node's SQL instance. Hardware which is to provide load balancing for the web application must support sticky sessions. Each web server must meet the recommended specification of a 1 GHz Pentium III-compatible processor and have 1.5 GB or more of RAM. The web servers will be used to run IIS, ColdFusion, and the ITL related web services.

Software specifications

The ANREU consists of the following software components.

- Internet Information Services (IIS) 6.0 or higher
- ColdFusion 8
- SQL Server 2005
- SQL Server 2005 Reporting Services

- Microsoft Messaging Queue components
- NET 2.0 Framework
- NET Web Services (C#)
- NET ITLListenerService (C#)
- Registry Management Application (RMA).

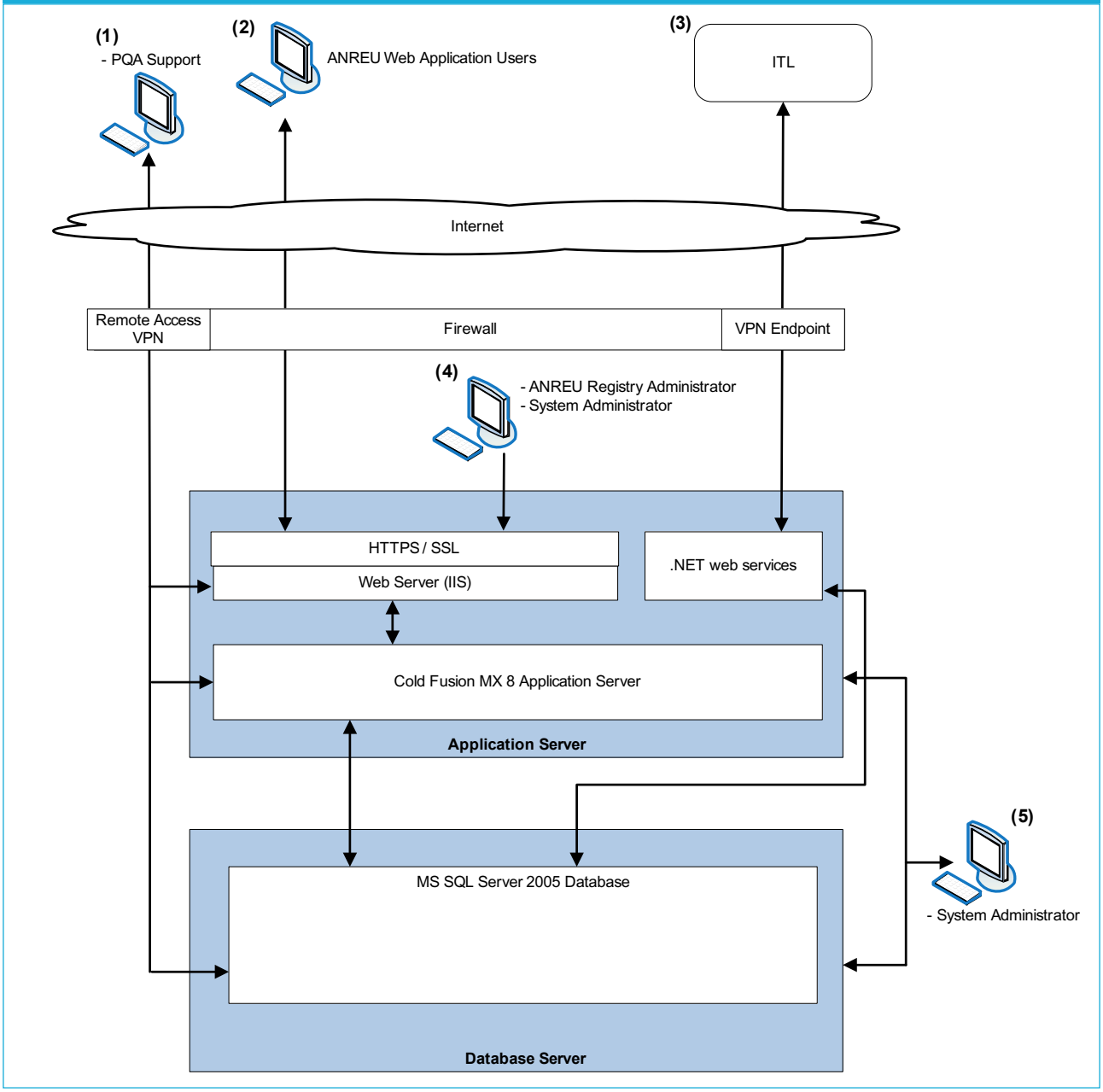
Communications with the UNFCCC International Transaction log are managed by software components deployed in IIS.

The ANREU contains the functionality to perform issuing, conversion, external transfer, (voluntary) cancellation, retirement and reconciliation processes using XML messages and web services as specified in V1.1 of the UN Data Exchange Systems (DES) document.

In addition, it also contains: 24-hour clean up, transaction status enquiry, time synchronisation, Data logging requirements (including, transaction log, reconciliation log, internal audit log and message archive) and the different identifier formats as specified in the UN DES document.

All formats used in the ANREU in transmitting information, including to the Independent Transaction

***Figure 3.5** Network specification: logical network topology (production environment)*



Log and acknowledging messages transmitted to other registries, are specified in the UN DES 1.1

In order to minimise discrepancies between the ANREU and the Independent Transaction Log, the following approach has been adopted:

- Communications between the registry and the ITL are via web services using XML messages—as specified in the DES 1.1. These web services, XML message format and the processing sequence are checked by the registry to ensure the compliance with DES 1.1.
- The registry validates data entries against the formats of information as specified in Annex F of the DES 1.1.
- The registry implements internal controls in accordance with the checks performed by the ITL—as documented in Annex E of the DES 1.1.
- All units that are involved in a transaction shall be earmarked internally within the registry; thereby preventing the units from being involved in another transaction until a response has been received from the ITL and the current transaction has been completed.
- The web service that sends the message to the ITL for processing will ensure that a message-received acknowledgement is received from the ITL before completing the submission of the message. Where no acknowledgement message has been received following a number of retries, the web service would terminate the submission and roll back any changes made to the unit blocks that were involved.
- Where a 24-hour clean-up message is received from the ITL, the existing web service would roll back any pending transactions and the units that were involved, thereby preventing any discrepancies in the unit blocks between the registry and the ITL.
- Finally, if an unforeseen failure were to occur, the data discrepancies between the registry and the ITL can be corrected via a manual intervention function within the registry. Following this, reconciliation will be performed to validate that the data is in sync between the registry and the ITL. If a discrepancy reoccurs in the registry, the following measures will be applied:
  - identification, and registration of the discrepancy
  - identification of the source of the discrepancy (DES, registry specifications, erroneous programming code)
  - elaboration of a resolution plan and testing plan
  - correction and testing of the software
  - release and deployment of the corrected software.

For the ANREU the following security measures have been implemented. In addition the Department of Climate Change is undertaking an external security review of the registry to ascertain key security risks and to ensure compliance with the Australian Government Authentication Framework (AGAF). Access to the registry is allowed via a personal username and password—allocated as a part of a registration process performed by the Department of Climate Change.

Users of the ANREU are divided into three security groups. These groups control the access and security at the application level. A user's login information is assigned to a user group, which determines what the user can and cannot do within the system.

The registry supports the following user groups.

The **system administrator group** has global authority throughout the registry. This user is responsible not only for the day-to-day functionality of the system, but also for administrative support. This may include user management, managing and setting batch jobs, and reviewing audit and transaction logs. This person is responsible for maintaining the technical environment of the ANREU, including all hardware, software, and network concerns. This includes scheduling regular data backups and restoring data in the event of a system.

The **Australian National Registry Administrator**, or program manager role, represents the person or persons responsible for all policy-based operations of the registry. This person will have access to all functionality that can be provided through the registry interfaces, but will not have direct access to the database tables and the web-application server. Should the need arise to access these resources, the registry administrator must co-ordinate with the system administrator. The registry administrator is responsible for such policy-based activities as account creation, approval of forwarding instructions, monitoring notifications and messages logs, and coordinating with the ITL for reconciliations.

Provisions are made for **account holders** to have access to the registry web application. The registry provides the capability to create users with restricted levels of access by which users would only be permitted to access data relevant to their own holdings

and activities. These permissions can be configured using the system administration functions.

In order to prevent operator errors, our registry software incorporates validations on all user inputs to ensure that only valid details are submitted for processing; The registry displays confirmation of user input to help the user to spot any errors that had been made and implements an internal approval process (input of relevant password details) for secondary approval for relevant operations before submitting the details to the ITL for processing.

Information publicly accessible through the user interface to the national registry

The following public reports are available through the user interface—no logon procedures are required to view these reports:

- a list of all accounts held within the national registry
- a list of all unit transactions made in the past calendar years
- a list of all Joint Implementation projects—including details of such projects
- a summary report of total unit holdings and transactions for the past calendar years.

The Internet address of the interface to its national registry: public information is available at swww.nationalregistry.climatechange.gov.au

Measures to safeguard, maintain and recover data in the event of a disaster

The servers (main and backup sites) that host the ANREU are in physically secure data centres fitted with secure access control systems. All data centres are fitted with smoke detection and automatic fire suppression systems. Anti-virus software upgrades are downloaded and installed autonomously on to the servers as soon as they are released.

A full backup of each database and an hourly transaction log backup during business hours takes place every day with the back-up media being held at an off-site third-party secure-storage facility. The database content will also be replicated at a minimum of 30 minute intervals to a secondary data centre location when the clustering environment is implemented. This will serve as the hosting platform for disaster recovery.

In the event of a disaster a decision will be taken (between the Department of Climate Change and the IT contract supplier) to invoke disaster recovery. This will involve:

- stopping all transactions to the main platform
- ensuring that the committed transactions are replicated to the DR site
- switching all external interaction with the main site over to the secondary location.

The IT contract supplier is committed to resuming the service for the department operators within eight hours of the decision being made.

Results of previous test procedures

Australia's independent assessment report is available from the UNFCCC website.

References

ABS (Australian Bureau of Statistics) 2004, *Detailed Energy Statistics Australia 2001–02*, cat. no. 4648.0.55.001, Canberra.

DCC (Department of Climate Change) 2009, *Australian National Greenhouse Accounts: National Inventory Report 2007* (2 vols), Department of Climate Change, Canberra.

IPCC (Intergovernmental Panel on Climate Change) 1997, *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories,* Volume 1, *Greenhouse Gas Inventory Reporting Instructions*; Volume 2, *Greenhouse Gas Inventory Workbook*; Volume 3, *Greenhouse Gas Inventory Reference Manual*, IPCC/OECD/IEA, Paris, France.

—— 2000, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Japan.

—— 2003, *Good Practice Guidance on Land Use, Land Use Change and Forestry*, Japan.

CHAPTER 4

Policies and measures

KEY DEVELOPMENTS

Since the Fourth National Communication on Climate Change, Australia has established a comprehensive and targeted set of policies and measures to meet its current and future commitments to reduce greenhouse gas emissions. The introduction of a cap-and-trade emissions trading scheme is the centrepiece of Australia's mitigation effort and will establish a price on carbon across the Australian economy and put Australia's emissions on a downward trend. Australian governments at all levels are also developing and implementing a range of policies and measures to complement this central market mechanism and assist the community in transitioning to a low-emissions economy.

Australia ratified the Kyoto Protocol in December 2007 and is on track to meet its Kyoto Protocol commitment to limit average annual greenhouse emissions to 108% of 1990 levels over the period 2008–12.

The Australian Government is committed to putting a price on carbon by establishing one of the most comprehensive cap-and-trade emissions trading schemes in the world, the Carbon Pollution Reduction Scheme (CPRS). This scheme will be the primary mechanism for achieving Australia's ambitious emissions reduction targets of 5 to 15% and 25% below 2000 levels by 2020, and 60% below 2000 levels by 2050.

In August 2009, the Australian Government passed laws to implement an expanded national Renewable Energy Target (RET) of 20% of Australia's electricity supply from renewable energy sources by 2020. The RET increases the previous Mandatory Renewable Energy Target more than fourfold—from 9500 gigawatt hours to 45 000 gigawatt hours in 2020—and will create incentives for a range of technologies including wind, biomass, geothermal and solar energy.

The Council of Australian Governments has agreed to a comprehensive 10-year National Strategy on Energy Efficiency to accelerate energy efficiency improvements for householders and businesses across all sectors of the economy. The strategy will provide a nationally consistent and coordinated approach to energy efficiency. The strategy is designed to complement the CPRS by addressing information, organisational and other non-market barriers.

The Australian Government is helping to smooth the transition to a low-emissions economy by establishing a $2 billion Climate Change Action Fund, which will provide targeted assistance to businesses, community sector organisations, workers, regions and communities. The fund will operate over seven years, from 2009–10 to 2015–16.

The Australian Government's $4.5 billion Clean Energy Initiative furthers innovation in clean energy generation and supports the research, development and demonstration of low-emissions technologies, including industrial-scale carbon capture and storage, solar energy, and non-solar renewable technologies.

Taking action on climate change by reducing Australia's greenhouse gas emissions is one of the Australian Government's highest priorities. As one of the hottest and driest continents on earth, Australia will be one of the nations affected most quickly and severely by the impacts of climate change. From extreme weather and higher temperatures to rising sea levels and more droughts, the projected impacts of unmitigated climate change pose a significant threat to Australia's economic and environmental security. Climate change challenges Australia's prosperity and risks undermining the viability of many coastal, rural and regional communities. The Australian Government ratified the Kyoto Protocol in December 2007 and implemented a comprehensive climate change policy agenda, building on the policies and measures implemented by previous Australian and state and territory governments.

This chapter outlines the governance structures, policy context and policy-making processes that underpin Australia's action on climate change. It also describes the major policies and measures that Australia is developing and implementing—the landmark Carbon Pollution Reduction Scheme (CPRS), which is augmented by a range of complementary and transitional measures to support the community and other key players to take action on climate change. These policies and measures constitute the first pillar of the Australian Government's climate change strategy: reducing Australia's greenhouse gas emissions.

4.1 Policy-making process

Australia's climate change policies and measures have been informed by an extended period of research, analysis, review and consultation. Policies are developed in close consultation with key stakeholders from government, industry, non-government organisations, environmental groups, scientists and the broader Australian community.

4.1.1 Governance arrangements

The Australian Government Department of Climate Change is leading the Australian Government's whole-of-government response to climate change. The department was established in December 2007 and is responsible for policy development and advice on climate change issues, both domestically and internationally. It works closely with other Australian Government departments and jurisdictions on policy development and the delivery of a national approach to addressing climate change. The department also liaises closely with Australian business, other levels of government and the community.

The Australian Government is also in the process of establishing a central climate change regulatory authority, the Australian Climate Change Regulatory Authority. This authority will administer the CPRS, the expanded national Renewable Energy Target (RET), and the National Greenhouse and Energy Reporting System. Further information on the authority is provided in 4.2.1.

The forum for cooperation between the Australian, state and territory governments, the Council of Australian Governments (COAG), established a Working Group on Climate Change and Water to ensure an effective national response to climate change. The working group was chaired by the Australian Government Minister for Climate Change and Water, Senator the Hon. Penny Wong, with representation from the Australian, state and territory governments.

In its work throughout 2008 and 2009, the working group:

- finalised the design of the expanded national RET scheme
- consulted with the states and territories on the CPRS
- agreed the principles for jurisdictions to guide their reviews of existing climate change measures and the development of new measures so that they complemented the CPRS
- developed energy efficiency policies
- developed a cooperative approach to climate change adaptation
- developed an approach to streamline greenhouse and energy reporting by business to state, territory and Commonwealth governments.

On completion of this work program, the working group was disbanded in July 2009. COAG will continue as the forum to promote cooperative action on climate change to complement the CPRS. The National Strategy on Energy Efficiency is being implemented through a COAG subgroup and COAG will also continue to progress work on adaptation in 2010.

4.1.2 Policy analysis, advice and development

To develop a comprehensive set of national policies and measures to reduce its greenhouse gas emissions, Australia has used a meticulous process of expert modelling, research and policy analysis. This has been integral to the development, analysis and streamlining of Australia's climate change policies and measures since Australia's Fourth National Communication on Climate Change.

The CPRS was grounded in four major analyses: the Garnaut Climate Change Review; economic modelling by the Australian Treasury; an extensive policy-making process that culminated in the Australian Government's *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future* (the CPRS White Paper, released in December 2008, which outlined analysis, stakeholder views and the Government's approach to key design features of the scheme); and a thorough strategic review of all existing climate change programs and policy needs.

4.1.3 Garnaut Climate Change Review

Headed by distinguished economist Professor Ross Garnaut, the Garnaut Climate Change Review was commissioned in April 2007 by the eight state and territory governments of Australia and the then leader of the federal opposition; the Australian Government joined the Garnaut Review in January 2008. The Garnaut Review examined the impacts of climate change on the Australian economy and recommended medium- to long-term policies and frameworks for acting on climate change. Released in September 2008, the final report of the Garnaut Review was the culmination of an extensive process that examined how Australia is likely to be affected by climate change, and how it can best contribute to mitigation efforts while adapting to the unavoidable impacts of climate change.

As part of its research and analysis, the Garnaut Review consulted with a wide range of experts and stakeholders in Australia and overseas: academics; officials; government departments and public bodies; business leaders and representatives; and non-government organisations. Between August 2007 and September 2008, the Garnaut Review initiated public forums and specialist lectures for more than 10 000 participants around Australia. A formal submission process was conducted that attracted almost 4000 submissions, and a number of reports were commissioned on the impacts of climate change on Australia, representing major contributions to the growing body of knowledge about these impacts. The methodology and results of the Garnaut Review's economic modelling also generated large volumes of analysis and information.

The Garnaut Review made clear that the costs to Australia of not acting on climate change would be greater than the costs of responsible mitigation. Moreover, the aggregate costs of action were estimated to be modest, whereas the benefits of action (and the costs of inaction) would increase over time, becoming more pronounced in the second half of the 21st century and beyond. The Garnaut Review observed that 'the overall cost to the Australian economy from tackling climate change is manageable and in the order of one to two-tenths of 1 per cent of annual economic growth' (Garnaut 2008, p. 296). It concluded that 'the costs of well-designed mitigation, substantial as they are, would not end economic growth in Australia, its developing country neighbours, or the global economy. Unmitigated climate change probably would' (Garnaut 2008, p. 268).

The Garnaut Review found that it is in Australia's national interests for a fair and effective global agreement to be negotiated and secured to deliver deep cuts in emissions consistent with stabilising concentrations of greenhouse gases at around 450 parts per million or lower. It also found that the most prospective pathway to this goal would be to embark on global action that reduces the risks of dangerous climate change and builds confidence that deep cuts in emissions are compatible with continuing economic growth and improved living standards.

The Australian Government accepted these findings in its White Paper of December 2008, which acknowledged that, due to its national circumstances—including its strong population growth, large share of energy- and emissions-intensive industries, and heavy reliance on fossil fuels for energy—Australia faces a relatively greater structural adjustment task to move towards a low-emissions future than many other developed countries.

4.1.4 Economic analysis of an Australian emissions trading scheme

In October 2008, the Australian Treasury published *Australia's Low Pollution Future: The economics of climate change mitigation*, a report modelling the potential economic impacts of reducing greenhouse gas emissions over the medium and long term. In partnership with many of Australia's leading economic modellers of climate change, the Treasury conducted one of the largest and most complex economic modelling projects ever undertaken in Australia. The modelling spanned global, national and sectoral scales and examined distributional impacts, including the implications of emissions pricing for the goods and services that households consume.

The Treasury modelling indicated that, with efficient policy settings, Australia and the world would continue to prosper while making the emissions cuts required to reduce the risks of dangerous climate change. The report examined four

different scenarios in which Australia and the world followed pathways to a low-emissions future with varying global stabilisation goals and requirements. In all four scenarios, the modelling showed prosperity increasing, albeit at a marginally slower rate than would occur under current policy settings, while ambitious stabilisation goals were achieved (CofA 2008a, p. vi).

The key conclusions from the modelling were that:

- early global action would be less expensive than later action—that is, in the event the world was to act the countries that acted early would be advantaged
- a market-based approach would allow robust economic growth into the future, even as emissions fell
- many of Australia's industries would maintain or improve their competitiveness under an international agreement to combat climate change.

The report noted that Australia's comparative advantage would change in a low-emissions world, presenting new opportunities for some sectors of Australia's economy, and that—with coordinated global action—most sectors of the economy would grow, with low-emissions sectors growing strongly and some emissions-intensive sectors maintaining or improving their international competitiveness (CofA 2008a, p. 28).

4.1.5 The CPRS White Paper

The Australian Government's CPRS legislation package was the culmination of an extensive process of analysis, consultation and policy deliberation.

Ongoing consultation throughout 2008 was based around the *Carbon Pollution Reduction Scheme: Green Paper* (the CPRS Green Paper), published in July 2008. The CPRS Green Paper sought stakeholder reactions to a range of design features. It outlined alternative approaches to implementing an emissions trading scheme while providing some indication of the Australian Government's predisposition on aspects of the scheme.

- More than 1000 submissions were received in response to the CPRS Green Paper and over 2400 people participated in consultation sessions and workshops held across the nation.
- The Green Paper also took into account previous work such as the 2007 reports of the former Prime Ministerial Task Group on Emissions Trading (*Report of the Task Group on Emissions Trading*) and the states' and territories' National Emissions Trading Taskforce (*Final Framework Report on Scheme Design*) and the June 2008 draft report of the Garnaut Climate Change Review.

In December 2008, the Australian Government released the policy paper on its proposed emissions trading scheme. The CPRS White Paper discussed major elements of the Australian Government's strategy, setting out its policy on:

- a medium-term target range for national emissions
- the design of the CPRS, which is to be a legislative cap-and-trade emissions trading scheme
- a range of complementary and supporting measures for households and industry.

The CPRS legislation was first introduced into the Australian Parliament in May 2009 and was subject to further consultation and amendments as the year progressed. The design of the CPRS and the complementary measures that have been developed to provide further support to households and industry and address the potential for market failures are outlined in 4.2.1 and 4.2.2.

4.1.6 Strategic review of Australian Government climate change programs

In December 2007, all jurisdictions committed to meeting a COAG request to review and streamline their existing climate change mitigation measures. The reviews aimed to ensure that all jurisdictions' climate change policies and measures were complementary to the CPRS.

The Australian Government established a strategic review of Australian Government climate change programs in February 2008. The review was commissioned to assess all existing Commonwealth climate change programs to:

- ensure they were complementary to emissions trading
- identify phase-out options for less efficient abatement programs and initiatives that would compromise the abatement incentives arising from emissions trading
- identify duplicative and overlapping programs that could be rationalised.

The review was tasked with developing a set of principles to assist the Australian Government in assessing whether existing programs would be

complementary to emissions trading, and to use in the development and implementation of future climate change measures that would be complementary to emissions trading.

The review was also asked to assess the appropriateness, effectiveness and efficiency of the existing suite of climate change programs. It considered a set of 58 active climate change programs, including those administered by the previous Australian Government and commitments implemented in the 2008–09 Australian Budget.

The review found that 31 programs were complementary to the CPRS (although some would require modification); 15 programs were transitional; and a further 12 programs would be superseded by the CPRS or by other new programs, or did not meet the complementarity principles. The review's findings and recommendations (CofA 2008d) assisted the Australian Government to ensure that climate change programs provide a comprehensive package to meet environmental objectives and to help transition Australia to a low-emissions economy.

4.2 Policies and measures at the national level

Australia is implementing a comprehensive and targeted set of national climate change policies and measures. A cap-and-trade emissions trading scheme will be Australia's primary policy tool for reducing greenhouse gas emissions, and will be complemented by a range of policies and measures designed to foster a low-emissions economy and support the efficient use and management of energy and resources. The Australian Government has also established a set of transitional policies and measures to assist the community and smooth the transition to a low-emissions economy.

The policies and measures outlined in this chapter underpin Australia's efforts to meet its current and future abatement targets under the Kyoto Protocol and its commitments at the domestic level. As a party to the Kyoto Protocol, Australia is on track to meet its Kyoto Protocol target to limit greenhouse gas emissions to 108% of 1990 levels over the period 2008–12.

A summary of the policies and measures currently included in Australia's emissions projections modelling is presented in Table 4.1 (pages 77–82). This table shows the estimated mitigation impact of those policies and measures in 2020.

4.2.1 Key features of the Carbon Pollution Reduction Scheme

The Australian Government is committed to establishing the CPRS as its primary policy tool for reducing greenhouse gas emissions. The CPRS is to be a legislative cap-and-trade emissions trading scheme. Its effect on emissions will be direct—it will set a limit on the total quantity of pollution that can be emitted. This direct limit will be important in guaranteeing that Australia meets its post-2012 internationally agreed emissions reduction target.

The CPRS will be one of the most comprehensive emissions trading schemes in the world, covering around 75% of Australia's emissions from commencement, including stationary energy, transport, industrial processes, fugitive and waste emissions, and all six Kyoto Protocol gases. Afforestation and reforestation will be covered on a voluntary basis, while agriculture will be excluded indefinitely.

The CPRS will apply obligations to businesses (at the level of each facility) that trigger a certain threshold, which is generally 25 000 tonnes of carbon dioxide equivalence. Obligations also apply to businesses that import, manufacture or supply fossil fuels and synthetic greenhouse gases, and these obligations may be transferred down the supply chain from supplier to recipient. Early estimates suggest that the CPRS will directly involve around 1000 businesses and other organisations in Australia.

To create incentives to reduce emissions outside the CPRS, emissions units will also be provided for offset projects that reduce emissions from sources that are not covered by the scheme, including agriculture, burning of savannas, deforestation and certain waste emissions excluded from the CPRS.

The CPRS will commence on 1 July 2011, and will be administered by an independent statutory authority—the Australian Climate Change Regulatory Authority.

The CPRS legislation was defeated in the Australian Parliament twice during 2009. Reflecting its commitment to action on climate change, the Government has indicated it will reintroduce the bills on the first parliamentary sitting day in 2010.

CPRS cap

The CPRS cap will be set to be consistent with Australia's national targets and international obligations. As the CPRS will not cover all sources of emissions across the economy, the scheme cap and Australia's national emissions trajectory will be

different. To guide business investment, the Australian Government will set and announce CPRS caps a minimum of five years in advance, to be extended by one year every year. The Australian Government may also announce CPRS cap gateways (a range within which future caps would be set) to provide guidance for longer-term cap setting while still allowing flexibility.

Eligible emissions units

There will be different types of eligible emissions units under the CPRS. The regulatory authority will issue a number of Australian emissions units equal to the CPRS cap for each year. The Australian emissions unit will be the basic unit of compliance and trade within the CPRS and will be classified as personal property. Australian emissions units and eligible international emissions units will also be regulated as financial products under existing legislation.

Liable entities will be able to use eligible international emissions units for compliance from 2012–13. Eligible international units currently comprise:

- certified emissions reductions created from emissions reduction projects in developing countries under the Kyoto Protocol's Clean Development Mechanism, with the exception of temporary certified emissions reductions and long-term certified emissions reductions
- emissions reduction units created from emissions reduction projects in developed countries under the Kyoto Protocol's joint implementation mechanism
- removal units issued by a Kyoto Party with an emissions reduction target on the basis of land use, land-use change and forestry activities.

Assigned amount units will not be recognised under the CPRS at commencement.

Future regulations may also make non-Kyoto international emissions units—such as the emissions units issued by another country or group of countries—eligible for surrender. This would enable Australia to link the CPRS with other emissions trading schemes in order to access a wider pool of abatement.

Administratively allocated emissions units

In addition to those sold at auction, some Australian emissions units will be administratively allocated as transitional assistance to emissions-intensive trade-exposed activities, to coalmines, and to coal-fired electricity generators under the Electricity Sector Adjustment Scheme.

Australia's adoption of a carbon cost ahead of many other countries may have a considerable impact on its businesses that produce significant levels of emissions and are trade-exposed. The Australian Government is committed to providing assistance to these businesses to reduce the risk of them relocating offshore and using production processes or inputs that are more emissions-intensive. Targeting assistance to these businesses will also help smooth the transition of the economy to a carbon cost. Free emissions units will be provided to emissions-intensive trade-exposed industries from 2011–12 at an initial assistance rate of 94.5% for the most emissions-intensive activities and at a rate of 66% for activities that are moderately emissions-intensive. Assistance will decline at a rate of 1.3% per year.

The Australian Government has established a Coal Sector Adjustment Scheme, which will provide the most emissions-intensive underground coalmines with a capped allocation of free permits over a five-year period. This will reduce the fugitive emissions liability for those mines to a level more comparable to that of other coalmines while abatement options are developed and implemented.

The Australian Government will also assist the electricity generation sector to make the transition to a low-emissions economy by allocating a fixed quantity of free emissions units, to be delivered over 10 years, under the Electricity Sector Adjustment Scheme. Assistance is focused on particularly emissions-intensive coal-fired generators.

The Climate Change Action Fund has also been established to help smooth the transition for businesses, community sector organisations, workers, regions and communities (see 4.2.3).

Auctioning of emissions units

The CPRS will commence with a one-year transitional fixed-price period in which Australian emissions units will be available for $10. The Australian Government will auction the majority of Australian emissions units from the commencement of normal trading (where the market sets the price of eligible emissions units) on 1 July 2012.

The first auction will be held in 2011, before the start of the CPRS. After the conclusion of the fixed-price period on 1 July 2012, auctions of emissions units will be held on a monthly basis.

Market stability

The CPRS has been designed to limit price volatility and ensure that emissions units are accessible to business. To this end, after the fixed-price period, it will allow unlimited banking (so that Australian emissions units created in one year can be used in a future year) and some limited borrowing of Australian emissions units. A transitional price cap will apply from 2012–13 to 2015–16, starting at around $46 per tonne and rising by 5% in real terms per annum. Liable entities will be able to access an unlimited store of additional Australian emissions units at this price to meet their obligations under the CPRS. This will set the maximum cost of compliance in the early years of the scheme.

Assistance to households

The CPRS will affect the prices of the goods and services that all households use. Goods that are emissions-intensive to produce will generally become more expensive. The Australian Government will assist all households, and particularly low-income households, to adjust to these changes. Every cent raised from the scheme will be used to help Australians—households and business—adjust to its impacts and invest in clean energy options.

Australian Climate Change Regulatory Authority

Australia's CPRS legislation establishes an independent regulator, the Australian Climate Change Regulatory Authority, to implement and administer the CPRS. The legislation also enables the authority to administer the *National Greenhouse and Energy Reporting Act 2007* and the *Renewable Energy (Electricity) Act 2000*. The authority will:

- calculate and allocate permits to eligible entities, under the CPRS assistance packages
- issue and manage the auction (including collecting revenue) or allocation of other permits
- maintain a registry of emissions permit owners
- assess the liabilities of eligible entities
- promote and enforce compliance with the CPRS.

It will also be responsible for the existing functions of the Office of the Renewable Energy Regulator and the Greenhouse and Energy Data Officer. Centralising responsibility under the Australian Climate Change Regulatory Authority will improve outcomes by reducing the risk of conflicts or gaps emerging between regulators with separate functions, and streamlining procedures for reporting and surrender, reducing the burden for businesses that would otherwise need to deal with several separate regulators.

To ensure an appropriate strategic context, direction and focus, a number of regulatory objectives and principles have been drafted to guide the authority's establishment. These principles are characterised by:

- fostering cooperative compliance among the regulated community by improving awareness and understanding of their obligations, including the provision of education and training programs
- adopting and maintaining a risk-based and intelligence-driven approach to preventing, detecting and remedying risks in a timely manner
- minimising the regulatory burden by reducing red tape and ensuring that regulatory work practices and systems are effective, efficient and result in minimal impact on affected parties
- engaging with the regulated community and, where appropriate, incorporating feedback into systems and processes
- incorporating an analytical, problem-solving ethos into the regulatory approach that identifies systemic problems, addresses the causal issues and fosters robust solutions
- ensuring that procedural justice is consistently applied to all parties so the system is equitable.

4.2.2 Policies and measures to complement the CPRS

To complement the CPRS, Australia is developing and implementing an extensive and considered range of policies and measures to assist in reducing Australia's greenhouse gas emissions. To be recognised as complementary, each measure must be closely targeted at a market failure that is not expected to be adequately addressed by the CPRS. In November 2008, the Council of Australian Governments endorsed a set of 'complementarity principles' to guide jurisdictions in reviewing and streamlining their existing climate change mitigation measures and, through this, creating a coherent and streamlined set of climate change measures.

The principles also state that complementary measures may be targeted to manage the impacts of the CPRS on particular sectors of the economy (for example, to address equity or regional development concerns) and should generally be implemented at the level

of government with the appropriate jurisdiction and capacity to deliver the measures.

The policies and measures outlined below are designed to foster a low-emissions economy by providing research, development and deployment opportunities for clean technologies, supporting the cleaner management and use of resources, and promoting energy efficiency across sectors.

Fostering a low-emissions economy

The 20% by 2020 Renewable Energy Target

The Australian Government has recently passed laws to implement an expanded national Renewable Energy Target (RET), which is designed to ensure that 20% of Australia's electricity supply comes from renewable energy sources by 2020. As a result, in 10 years' time, the amount of electricity supplied using energy sources such as solar, wind and geothermal will be approximately equal to Australia's current level of household electricity use.

Australia's transition to a low-emissions future will require a significant transformation in the electricity sector given that electricity generation accounts for more than one-third of Australia's current greenhouse gas emissions. The national RET will help to prepare the electricity sector to contribute to the significant emissions reductions that are needed to address climate change.

While the CPRS will help to bring renewable energy technologies into the market over time, the RET will accelerate their uptake, helping the energy sector to make the transition to lower carbon production earlier than would otherwise occur. The RET will operate in parallel with the CPRS and will conclude in 2030, by which time the CPRS is expected to be the primary driver of renewable energy.

The RET increases the target of the previous Mandatory Renewable Energy Target scheme (reported in Australia's Fourth National Communication on Climate Change) more than fourfold—from 9500 gigawatt hours to 45 000 gigawatt hours in 2020—and will encourage innovation in a range of technologies including wind, biomass, geothermal and solar energy.

Modelling shows that implementation of the expanded RET, together with the CPRS, is expected to lead to around $19 billion in investment in the renewable energy sector in the decade to 2020 (McLennan Magasanik Associates 2009, p. 34).

The RET is designed to encourage the deployment of both large- and small-scale renewable energy technologies, from large power stations to household renewable energy systems. As such, the RET includes 'Solar Credits' (see page 66), which are designed to reduce the costs for households, businesses and community groups that install small-scale renewable energy generation units.

Clean Energy Initiative

In May 2009, the Australian Government announced the $4.5 billion Clean Energy Initiative. This initiative is designed to support a series of measures to encourage further innovation in clean energy generation and low-emissions technologies, including industrial-scale carbon capture and storage, solar energy, and non-solar renewable technologies. The Clean Energy Initiative complements the CPRS and RET by supporting the research, development and demonstration of low-emissions energy technologies.

The main components of the Clean Energy Initiative are the Carbon Capture and Storage Flagships Program, the Solar Flagships Program, and the Australian Centre for Renewable Energy.

Carbon Capture and Storage Flagships Program

The Carbon Capture and Storage Flagships Program provides $2 billion over nine years to fund the construction and demonstration of commercial-scale integrated carbon capture and storage projects. The program is undertaking pre-feasibility assessments on four projects in Western Australia, Queensland and Victoria. These projects will form the basis of Australia's contribution to 20 commercial-scale carbon capture and storage projects worldwide by 2020. Project funding under this program is subject to a competitive process, with the intention to fund up to four projects across a range of carbon capture technologies and storage geologies. Indicative priorities include:

- multi-user infrastructure: development of storage sites in a high-emissions region, with pipeline infrastructure to support the transport of CO_2 from regional emissions sources
- integrated capture and storage: projects that demonstrate technologies and geologies for capture and storage of CO_2 from coal-fired power stations. Capture technologies may include coal gasification, post-combustion capture and oxy-firing.

The Carbon Capture and Storage Flagships Program builds on the National Low Emissions Coal Initiative,

NATIONAL GREENHOUSE AND ENERGY REPORTING SYSTEM

In 2006, the Council of Australian Governments identified high-quality emissions reporting, integrity of emissions data and public reporting as fundamental to any climate change action agenda. In early 2007, the Australian, state and territory governments agreed to establish a national framework for mandatory reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy consumption and energy production by corporations, and to streamline 26 different reporting systems.

The high-quality, detailed information gathered under the *National Greenhouse and Energy Reporting Act 2007* (the NGER Act) has already helped, and will continue to help, government and industry to understand more completely and accurately where opportunities for emissions reductions and energy efficiencies exist, and what effect mitigation actions are having across the economy. This will, in turn, inform the most effective policy and program interventions on climate change mitigation.

The Australian Government chose a national legislative approach for greenhouse and energy reporting to increase the effectiveness of national emissions and energy reporting across industry sectors, ensure the reliability and consistency of methods, and improve the quality, completeness and accessibility of data.

Data collected under the NGER Act will:

- underpin the CPRS
- inform government policy formulation and the Australian public
- meet Australia's international reporting obligations
- assist Australian, state and territory government programs and activities
- avoid the duplication of similar reporting requirements in states and territories.

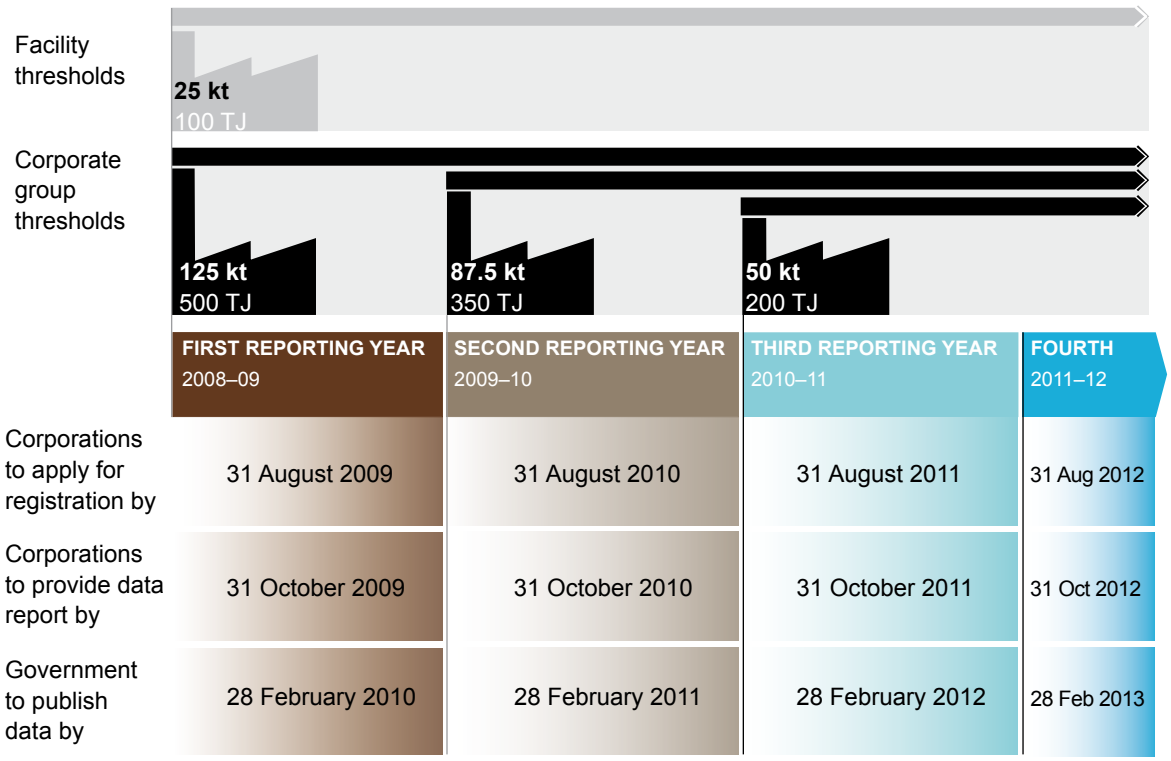
Requirements of the NGER Act

Since July 2008, corporations that meet or exceed specified thresholds are required to report their annual greenhouse gas emissions (the six Kyoto gases) and energy production and consumption to the regulator of the NGER Act, the Greenhouse and Energy Data Officer. This information is reported for all facilities over which members of their corporate group (which may include subsidiaries, joint ventures or partnerships) have operational control. Figure 4.1 shows the thresholds (at both facility and corporate level) and the due dates for registering and reporting to the regulator. Data collected under the NGER Act will be published annually.

Subordinate legislation established under the NGER Act provides greater detail about corporations' obligations, in particular, specific requirements relating to measurement of greenhouse gas emissions and energy. The NGER Act requires corporate reporting based on the concept of operational control as adapted from the World Business Council on Sustainable Development/World Resources Institute Greenhouse Gas Protocol. The definition of a facility has been expanded to include all emissions and energy consumption/production associated with a process, including ancillary activities. By requiring corporations to report at this level, Australia will achieve a far more detailed and holistic understanding of its greenhouse gas emissions and energy use and production.

The legislation provides the Greenhouse and Energy Data Officer with a range of monitoring and enforcement powers including third-party auditing and fines for chief executives of corporations. The compliance and enforcement policy, however, focuses on education and communication to maximise voluntary compliance in the early years. The Greenhouse and Energy Data Officer will be integrated into the Australian Climate Change Regulatory Authority when it commences operations.

***Figure 4.1** Thresholds and due dates for reporting under the NGER Act*



Source: DCC 2008.

Key functions of the NGER Act

The NGER Act aims to reduce the regulatory burden for business by streamlining reporting across a number of national, state and territory greenhouse and energy programs. Many of these programs have evolved separately, giving rise to different reporting requirements across the country. This had the potential to impose increasing costs on business. In July 2009, the Australian, state and territory governments released the National Greenhouse and Energy Reporting Streamlining Protocol to facilitate a standard national approach to collecting greenhouse and energy information.

Chapter 3 provides more information on the use of the NGERS for the national inventory.

which includes research, demonstration, mapping and infrastructure elements, and the Global Carbon Capture and Storage Institute. Together, these provide a total of $2.5 billion in support of the development and deployment of technologies to reduce greenhouse gas emissions.

Solar Flagships Program

The Australian Government is providing $1.5 billion over six years for the Solar Flagships Program. The program will support the construction and demonstration of large-scale solar power stations in Australia.

The Solar Flagships Program is expected to comprise up to four solar power stations operating within the electricity market, with a target capacity of 1000 MW. Project funding under the program will be subject to a competitive process, with the intention to fund projects across a range of solar technologies. There are two primary classes of solar technology—solar thermal and photovoltaic—and several competing technologies within each of these classes.

In addition, the Government has provided $100 million for an Australian Solar Institute. The institute is expected to be the vehicle through which the economic and technical learning is shared with the Australian and global solar community.

Australian Centre for Renewable Energy

The Australian Centre for Renewable Energy will promote the development, commercialisation and deployment of renewable technologies. The centre will have the flexibility to operate along the full innovation chain, from research through to deployment. It will be a one-stop shop for Australian renewable energy businesses, consolidating more than $560 million of renewable energy investment. This funding also includes $150 million for new initiatives.

The centre's activities are expected to include:

- supporting focused, collaborative, high-priority technology research with the ultimate aim of advancing new technologies and lowering the cost of existing technologies in the marketplace
- supporting and advising government, industry and the community on the promotion, development and implementation of renewable technologies and relevant research and development in essential renewable-related systems
- supporting growth in skills and capacity in renewable technologies for the domestic and international markets.

The Australian Government will establish the Australian Centre for Renewable Energy in 2009–10. The new centre will manage existing Australian Government renewable energy programs, including the Renewable Energy Demonstration Program, the Geothermal Drilling Program and the Second Generation Biofuels Research and Development Program (Gen 2).

The **Renewable Energy Demonstration Program** is a $300 million competitive grants program designed to accelerate the commercialisation and deployment of new renewable energy technologies for power generation in Australia. The program aims to demonstrate the technical and economic viability of renewable energy technologies for power generation through:

- enabling large-scale installations
- supporting the development of a range of renewable energy technologies for power generation in Australia
- enhancing Australia's international leadership in renewable energy technology for power generation development
- attracting private sector investment in renewable energy power generation.

Renewable energy technologies for power generation that have already reached the stage of commercial roll-out are not eligible unless the project can demonstrate significant innovation over the existing application of the technology.

Renewable energy technologies eligible for the Renewable Energy Demonstration Program include geothermal, wind, biomass, hydro systems, ocean energy and combination technologies (combining those listed above and including energy storage). Grants require private sector contributions of at least two dollars for every dollar of Australian Government funding provided.

The $50 million **Geothermal Drilling Program** was launched in August 2008. Geothermal energy holds the promise of being a renewable energy source with zero greenhouse gas emissions that can operate 24 hours a day to provide critical, large-scale, baseload power for Australian homes and industries. The program is designed to help companies with the high cost of drilling geothermal wells for proof-of-concept geothermal projects. It is a competitive, merit-based grants program provided as dollar-for-dollar matched funding and is capped at $7 million for each project.

AUSTRALIA'S ACTION ON CARBON CAPTURE AND STORAGE

Coal is likely to continue to be a major world energy source over the coming decades. It is the most widely distributed fossil fuel in the world, and the technology to generate electricity from coal is relatively simple and inexpensive. The International Energy Agency forecasts that world energy demand will increase by 45% between 2006 and 2030, and that despite the growing importance of renewable energy, fossil fuel use will continue to grow through this period (IEA 2008). For energy security reasons, coal will remain a key part of the global energy supply. It is likely to remain the main source of Australia's energy supply into the future, and a continuing major component of Australia's export revenue.

Carbon capture and storage is one of many options that the Australian Government is pursuing to help Australia and the world reduce greenhouse gas emissions. In addition to the Carbon Capture and Storage Flagships Program under the Clean Energy Initiative, the Australian Government is implementing new policies and measures to develop carbon capture and storage technologies both domestically and internationally.

Australia's carbon capture and storage legislation

The Australian Government recognises that the key to establishing a comprehensive regulatory regime in this area is to make Australia 'storage ready'. Legislation to enable carbon capture and storage has been passed by the Australian Government and the Victorian, Queensland and South Australian governments, and is under consideration in the remaining states and territories.

Australian Government legislation (the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*) provides for access and property rights for greenhouse gas injection and storage activities in Australian offshore waters. Major features of the legislation include a title system similar to that used for petroleum; regulation to ensure safe and secure storage; mechanisms for managing interactions with the petroleum industry; and site closure and the treatment of long-term liability. The legislation allows industry to explore for and develop carbon dioxide storage sites in offshore areas. Regulations and guidelines for the greenhouse gas storage provisions of this legislation are currently under development and are expected to be released for public comment in late 2009.

Commonwealth greenhouse gas acreage release

With the legislative background established, the Australian Government took the next major step in making Australia storage ready by making acreage available for industry to explore for potential storage sites. In March 2009, the Australian Government released 10 areas available for bids for the rights to explore for storage sites. The release is the first step in a process whereby prospective carbon capture and storage companies can obtain the necessary property rights—and the investment certainty—that they need to proceed with commercial storage operations.

Global Carbon Capture and Storage Institute

In September 2008, the Australian Government announced the establishment of the Global Carbon Capture and Storage Institute, and committed funds of $100 million per annum to it over the medium term. The Australian-based institute will help deliver the G8's goal, agreed in July 2008, to develop at least 20 fully integrated industrial-scale demonstration projects around the world to accelerate the broad deployment of carbon capture and storage technology by 2020. The institute was established in Canberra as a not-for-profit company in June 2009.

The Prime Minister launched the Global Carbon Capture and Storage Institute in L'Aquila, Italy in July 2009, and released the final list of 131 foundation members, which includes 23 national governments and more than 100 companies and organisations.

National Low Emissions Coal Initiative

The Australian Government established the $400 million National Low Emissions Coal Initiative in July 2008 to accelerate the development and deployment of technologies that will reduce emissions from coal use, with a major focus on carbon capture and storage. As part of this initiative, the Australian Government established the National Low Emissions Coal Council to bring together government, industry and coal researchers to develop a strategy to underpin the broad deployment of low-emissions coal technologies in Australia. The council's strategy will be complemented by the National Carbon Mapping Infrastructure Plan, which will drive prioritisation of, and access to, Australia's geological carbon storage capacity. The implementation plan is being developed by the Carbon Storage Taskforce, which includes representatives from relevant industries, geological survey agencies, unions, governments and non-government organisations.

The program will help to demonstrate proof-of-concept in a variety of locations, and thereby demonstrate the robustness of the technology to private sector investors.

The Australian Government's **Second Generation Biofuels Research and Development Program** (Gen 2), announced in 2008, is providing $15 million to support the research, development and demonstration of new biofuel feedstocks and technologies. The program will provide support for the research, development and demonstration of new biofuel technologies, which could contribute to the sustainable development of the biofuels industry in Australia. In August 2009, the Australian Government announced seven successful recipients under the program.

Technology roadmaps

In April 2007, COAG announced the development of technology roadmaps to advance clean energy. COAG has released technology roadmaps for:

- hydrogen and fuel cells
- solar thermal energy
- geothermal energy.

The Australian Government has developed a Geothermal Industry Development Framework to accelerate development of geothermal energy in Australia.

Advanced Electricity Storage Technologies Program

The Australian Government has provided $20.4 million for the Advanced Electricity Storage Technologies Program, which supports the development and demonstration of efficient electricity storage technologies for use with variable renewable generation sources such as wind and solar. The program aims to identify and promote strategically important advanced storage technologies, in order to increase the ability of renewable energy–based electricity generation to contribute to Australia's electricity supply system. Advanced storage technologies for electricity applications include batteries and electro-mechanical, chemical and thermal storage technologies in either on-grid or off-grid situations.

Clean Energy Innovation Centre

The Clean Energy Innovation Centre is one of six innovation centres and six manufacturing centres under Enterprise Connect, a $50 million per year Australian Government initiative designed to improve innovation and increase the competiveness of eligible Australian small and medium-sized enterprises. The centre provides specialist advice and services to help these enterprises become more innovative and efficient within the clean energy sector. Core services include business reviews at no financial cost to eligible firms and grant assistance to implement recommendations flowing from the business reviews.

Control of emissions from synthetic greenhouse gases

Synthetic greenhouse gases (SGGs) are used and emitted by a wide range of Australian industries, including the refrigeration and air-conditioning, foam-blowing, fire-prevention, aerosols and solvents industries. While emissions of these gases do not contribute significantly to Australia's emissions, they have comparatively high global warming potentials and, given the expected increase in their use, there is significant potential for emissions of them to grow in the future. This increase is driven largely by industries covered by the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) replacing ozone-depleting substances (ODSs) with SGGs.

The *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* enables Australia to meet its international obligations under the Montreal Protocol and the UNFCCC. The Act applies consistent controls on the use of ODSs, and SGGs used to replace ODSs, to minimise the emission of these substances to the atmosphere. It establishes a system of controlled substance licences and reporting requirements, for the import, export or manufacture of ODSs, HFCs and PFCs. Controls on SGGs were included in the Act's ambit in 2003.

In 2005, the Australian Government established a permit scheme to regulate the use and handling of ODSs and SGGs in the refrigeration and air-conditioning and fire-protection industries using the 1995 Ozone Protection and Synthetic Greenhouse Gas Management Regulations. This scheme established minimum industry standards to reduce emissions of ODSs and SGGs in their use and disposal.

In January 2009, it was made illegal to emit ODSs and SGGs other than in prescribed circumstances. In 2009, amendments were made to the legislation to help minimise ODS and SGG emissions and to streamline compliance and enforcement activities.

The Australian Government is undertaking a research project to obtain data on emissions of ODSs and SGGs from stationary motor vehicles. The Australian Government has previously undertaken studies on emissions of ODSs and SGGs from landfills. The data collected from both studies will be used to refine existing models and assist in formulating Australia's National Greenhouse Gas Inventory.

Supporting energy efficiency

National Strategy on Energy Efficiency

In July 2009, the Council of Australian Governments agreed to a comprehensive 10-year National Strategy on Energy Efficiency to accelerate energy efficiency improvements for householders and businesses across all sectors of the economy. This commitment will be delivered by the Australian Government and state and territory governments through the National Partnership Agreement on Energy Efficiency.

The strategy provides a nationally consistent and coordinated approach to energy efficiency, and encompasses many individual policy and program measures expressed within four key themes:

- assisting households and businesses to transition to a low-carbon future
- reducing impediments to the uptake of energy efficiency
- making buildings more efficient
- government working in partnership and leading the way.

The strategy is designed to complement the CPRS by addressing information, organisational and other barriers that are preventing the efficient uptake of energy efficiency opportunities.

The strategy brings together existing and new initiatives to encourage more efficient appliances, equipment, buildings and industry operations. It incorporates elements of the superseded Action on Energy Efficiency program and includes all current measures in the National Framework on Energy Efficiency. The strategy is wide-ranging in scope and includes a package of measures to improve the efficiency of the transport sector; energy market and network initiatives; consumer advice, education and information programs; energy efficiency data collection and benchmarking; and development of a consistent, outcomes-based national framework for setting, assessing and rating building energy standards to drive energy efficiency in Australia's building stock.

In the industry and business sector, initiatives will help ensure that businesses have adequate knowledge, skills and capacity to make informed choices to improve their energy efficiency. The strategy includes targeted outreach measures, support to identify and implement projects with high energy savings potential, and help to assess and prioritise energy efficiency opportunities. Action will also be taken to identify skills gaps and support the development of the skills and capacity of the energy services sector, particularly in the area of energy efficiency advice, audit and assessment.

Energy efficiency assistance components of the Climate Change Action Fund (see page 72) and the Australian Carbon Trust (see page 65) form part of the complement of measures under the National Strategy on Energy Efficiency designed to assist business in making the transition to a low-carbon future.

The strategy also encompasses measures to improve the energy efficiency of government operations. Australian, state and territory governments will jointly develop a national framework to improve the performance of their building stock. Greater emphasis will also be placed on energy efficiency as part of broader improvements to the sustainable procurement practices of governments.

Key early-start programs delivered under the strategy are summarised below.

National Energy Efficiency Skills Initiative

Under the National Energy Efficiency Skills Initiative, the Ministerial Council on Energy will identify energy efficiency skills gaps throughout the economy, and work with industry and educational groups to develop appropriate training courses, accreditation standards and supporting systems. The strategy's reforms will improve relevant skills in the Australian workforce.

Equipment Energy Efficiency (E3) Program

The Equipment Energy Efficiency (E3) Program is a set of coordinated programs that deliver economic and environmental benefits to the community. The program—which is co-funded by the Australian Government, state and territory governments and the New Zealand Government—focuses on initiatives that require a nationally consistent framework to improve energy efficiency and reduce greenhouse emissions from household appliances and equipment, and commercial and industrial equipment. E3 covers the technical, legal and administrative aspects of national appliance and equipment energy efficiency initiatives, in particular mandatory minimum energy performance standards and energy efficiency labelling. Products are considered for inclusion within the program on the basis that the community will benefit from their regulation. The individual product energy efficiency target is either the equivalent of a world-best regulatory target or a more stringent level developed specifically for Australia.

Energy efficiency requirements

- Residential buildings: In 2006, the minimum energy efficiency standard for houses in the Building Code of Australia was increased to five stars. In 2009, COAG agreed to increase the standard for all housing to six stars, and include standards for hot water and lighting, for implementation in 2011, subject to regulatory impact analysis.
- Commercial buildings: The energy efficiency provisions in the Building Code of Australia for all new commercial buildings will be significantly raised from 2010, subject to regulatory impact analysis. The new provisions will seek to minimise energy use through improvements to the building fabric, glazing, artificial lighting, and heating, ventilation and air-conditioning systems in new commercial buildings from 2010.

Mandatory disclosure requirements

- Energy performance for residential buildings: In July 2009, COAG committed—subject to regulatory impact assessment requirements—to phase in by May 2011 mandatory disclosure of residential building energy, greenhouse and water performance at the time of sale or lease, commencing with energy efficiency. This mandatory disclosure is intended to provide house buyers and renters with information to make more informed decisions and help consumers consider the energy efficiency of houses in making purchasing decisions. Performance disclosure should also encourage voluntary efficiency improvements by home owners as they upgrade their properties.
- Commercial building energy efficiency: A new national system for the mandatory disclosure of commercial building energy efficiency is being developed for implementation in 2010, beginning with large office buildings. The scheme will require office buildings with areas of 2000 square metres or larger to disclose to prospective buyers or tenants a base building star rating and associated energy efficiency information at the point of sale, lease or sub-lease.

Commercial building rating tools

A new national building energy standard setting, assessment and rating framework is being developed for implementation in 2011. As part of this initiative, the National Australian Built Environment Rating System suite of rating tools for commercial buildings will be enhanced through a more effective national governance framework. These measures will facilitate greater transparency and consistency across jurisdictions of rating tools for sustainable design and performance of commercial buildings.

Heating, Ventilation and Air Conditioning High Efficiency Systems Strategy

The Heating Ventilation and Air Conditioning (HVAC) High Efficiency Systems Strategy is designed to achieve long-term improvements in the energy efficiency of HVAC systems, particularly in commercial building applications. The program is aimed at whole-of-life improvements in HVAC efficiency, encompassing design, manufacture, installation, operation and maintenance. The HVAC strategy's targeted gains are largely in the maintenance and operation of existing systems in buildings, and through the establishment of national standard systems of documentation of the design, installation, operation and maintenance of equipment.

Phase-out of inefficient incandescent lighting

The phase-out of inefficient incandescent light bulbs, announced by the Australian Government in February 2007, continues as part of the National Strategy on Energy Efficiency. Working with the states and territories, the Australian Government will gradually phase out all inefficient incandescent light bulbs and encourage the uptake of efficient lighting such as compact fluorescent lamps. The move to more efficient lighting is expected to save around 30 terawatt hours of electricity and 28 million tonnes of greenhouse gas emissions between 2008 and 2020.

Phase-out of greenhouse-intensive water heaters

A 10-year low-emissions pathway for the hot-water industry has been established under the National Hot Water Strategic Framework—agreed by the Ministerial Council on Energy in December 2008—comprising a mix of regulatory and industry development elements. From 2010 and 2011, the installation of electric resistance hot-water systems and electric hot-water systems will not be permitted in certain types of residences with access to reticulated or piped gas, except where exemptions apply. For new apartments without access to reticulated gas, the phase-out of electric resistance hot-water systems will occur between 2012 and 2015, depending on the results of further investigation of the feasibility of low-emissions water heating options for such buildings.

Prime Minister's Task Group on Energy Efficiency

A new Prime Minister's Task Group on Energy Efficiency will be established in 2010 to provide recommendations to the Australian Government on developing a new energy efficiency mechanism or mechanisms. The Task Group will report to the Government by mid-2010 on options for introducing a new energy efficiency mechanism. The Task Group will be asked to assess and provide advice on the most economically and environmentally effective energy efficiency mechanisms that could be considered by the Australian Government to complement the CPRS and the RET. The Task Group will seek input from stakeholders in assessing options and providing recommendations.

Smart Grid, Smart City demonstration project

In the 2009–10 federal budget, the Australian Government committed up to $100 million in partnership with the energy sector for the development of the National Energy Efficiency Initiative's Smart Grid, Smart City demonstration project. This will establish a commercial-scale, integrated system of renewable energy, smart grid and smart meter technology and infrastructure within a city, town or region. It will bring together electricity power generation, transmission and distribution providers as well as private partners and IT experts, and will inform the wider national deployment of smart grid technologies.

The phrase 'smart grid' refers to a range of technologies applicable at all stages of the electricity supply chain, from the generator to the transmission and distribution networks, through to the meter and into the home or business. It includes smart meters, automated substations, current and voltage sensors, and data management systems that integrate energy, consumer and environmental information to effectively predict supply and demand. Smart meters alone enable a range of activities such as remote meter reads, real-time energy consumption information and economically efficient time-of-use retail pricing, and direct and remote load control of household appliances by energy retailers or distributors to smooth demand peaks and save consumers money.

Australian Carbon Trust

The Australian Government has committed $75.8 million from 2009–10 over five years to establish the Australian Carbon Trust to support action on climate change by business and households. The trust will initially manage two initiatives, the Energy Efficiency Savings Pledge Fund and the Energy Efficiency Trust.

The Australian Carbon Trust is expected to be established as a corporation in early 2010. It will work closely with the Carbon Trust in the United Kingdom.

The **Energy Efficiency Savings Pledge Fund** will have two key functions:

- It will enable households to directly contribute to achieving emissions reductions beyond Australia's targets. Households will be able to make donations to the Pledge Fund and the Pledge Fund will purchase and retire Australian emissions units, or offsets approved under the National Carbon Offset Standard, on their behalf. The use of the Pledge Fund will be entirely voluntary and contributions will be tax deductible.
- The Pledge Fund will also provide web-based information on energy efficiency and greenhouse gas emissions reduction opportunities for households. This will include tools to enable households to identify energy savings and simply calculate their energy use and dollar savings that result from energy efficiency activities. Households could then choose to pledge the resulting savings, or any other amount, to the Pledge Fund.

Through the **Energy Efficiency Trust**, the Australian Government will provide $50 million in seed funding to promote energy efficiency in the business sector.

The Energy Efficiency Trust will demonstrate innovative approaches to energy efficiency investment by business with the aim of showcasing and mainstreaming these approaches across the private sector. It will bring together public and private seed funding, business skills and culture and technical knowledge to leverage investment in energy efficiency activities in commercial buildings and other business operations.

By showcasing commercially viable energy efficiency opportunities, the Energy Efficiency Trust will increase awareness among businesses of the benefits of energy efficiency and facilitate the growth of private sector capacity.

Energy Efficient Homes Package

Established in February 2009, the Australian Government's $3.2 billion Energy Efficient Homes Package is a key part of the Australian Government's response to the global financial crisis of 2008—the Nation Building – Economic Stimulus Plan. The package recognises that two of the most effective

residential energy efficiency measures for the existing housing stock are retrofitting ceiling insulation and installing more energy efficient hot-water units. Subsidies are provided to households consistent with publicly available guidelines and are subject to a compliance audit framework. The package emphasises skills development and matching people to jobs and is providing significant employment support in the energy efficiency sector, helping the environment and boosting the economy. The Energy Efficient Homes Package as a whole is anticipated to reduce greenhouse gas emissions by between 35 and 45 million tonnes by 2020.

Under the **Home Insulation Program**, non-means-tested assistance of up to $1200 is available to help eligible owner-occupiers, landlords and tenants install new ceiling insulation in their existing privately owned homes, rental and other properties. This assistance will help householders reduce their energy consumption and save on energy bills.

The Home Insulation Program is anticipated to substantially reduce household greenhouse gas emissions. Ceiling insulation made of glass wool or rock wool will remain effective for decades, so the emissions abatement benefits of the program will continue to accrue for many years.

Under the **Solar Hot Water Program**, the Australian Government is offering a rebate of $1600 to install a solar hot-water system or $1000 to install a heat pump hot-water system. The Solar Hot Water Rebate will help people save money on their power bills and reduce their household's greenhouse gas emissions. Water heating is the largest single source of greenhouse gas emissions from the average Australian home, accounting for around 25% of home energy use (excluding the family car). Installing a climate-friendly hot-water system can save a family up to $700 from its energy bills each year.

Employment support and training

In July 2009 as part of the package the Australian Government signed a memorandum of understanding with the National Employment Services Association, Master Builders Australia, the Housing Industry Association and the Construction Forestry Mining Energy Union. Under the terms of the memorandum, the Australian Government, industry and Job Services Australia providers will identify labour needs, work together to meet these needs, and connect job-seekers with relevant training and employment opportunities.

Energy Efficiency Opportunities

The Australian Government requires Australian corporations that use more than 0.5 petajoules of energy per year—equivalent to the annual energy usage of around 10 000 Australian households—to participate in the Energy Efficiency Opportunities program. These companies must undertake a rigorous and comprehensive assessment of their energy use to identify cost-effective energy efficiency opportunities and report to the Australian Government and public on their business response. The Energy Efficiency Opportunities legislation came into effect in July 2006 and the program is now halfway through its first five-year cycle. The program aims to improve:

- identification and uptake of cost-effective energy efficiency opportunities
- productivity while reducing greenhouse gas emissions
- energy management systems, behaviours and technology within large energy-consuming companies.

Some 227 corporations have registered for the program. These companies comprise 45% of total Australian energy end use and 60% of business energy end use.

The 199 companies that reported by December 2008 had assessed nearly 65% of all company energy use. They reported publicly that they had committed to implementing energy savings opportunities totalling more than 37 petajoules. This is equivalent to abating four million tonnes of CO_2 equivalent and is worth $435 million in net financial savings per year in aggregate to participating companies. Fourteen per cent of EEO companies are committed to implementing opportunities that will save more than 10% of their assessed energy use.

Solar Credits Scheme

Solar Credits are incentives under Australia's Renewable Energy Target (RET) (see page 57) and are designed to boost support for households, businesses and community groups that install eligible small-scale solar photovoltaic (PV), wind and micro-hydro systems. Solar Credits replaced the rebates for rooftop solar PV under the Solar Homes and Communities Plan in 2009.

The RET supports the deployment of both large- and small-scale renewable energy technologies in Australia's electricity mix by guaranteeing a market for additional renewable energy generation, using a

mechanism of tradeable renewable energy certificates backed by a legislative obligation.

The RET allows owners of small-scale solar PV systems, small wind turbines and micro-hydro systems to create—at the time of installation—renewable energy certificates equivalent to the output of up to 15 years' operation. Solar Credits further assist with the upfront costs of installing these small-scale systems by multiplying the number of renewable energy certificates that are able to be created for eligible systems installed on or after 9 June 2009.

The level of support provided by Solar Credits depends on factors including the size of the certificates' multiplier (initially five times, stepping down annually from mid-2012), their market price, and the location of the system. Solar Credits apply to the first 1.5 kilowatts of capacity installed. Generation from capacity above 1.5 kilowatts will still be eligible for the standard 1:1 rate of creation of renewable energy certificates.

Solar Credits will be phased out by 2015–16. This recognises that technology costs will be going down, and that the CPRS will also be providing incentives for renewable technologies.

National Solar Schools Program

The Australian Government's $480 million National Solar Schools Program offers eligible primary and secondary schools grants of up to $50 000 to install solar and other renewable power systems, solar hot-water systems, rainwater tanks and a range of energy efficiency measures including insulation, energy efficient lighting and ceiling fans. The program began in July 2008 and finishes in June 2015. In allowing schools to generate their own electricity from renewable sources, the program aims to help schools to improve their energy efficiency and reduce their energy consumption; adapt to climate change by making use of rainwater collected from school roofs; and provide educational benefits for students and their communities. The program also supports the growth of the renewable energy industry. There has been a strong response to the program; more than half of the approximately 10 000 eligible schools have registered to participate since July 2008.

Solar Cities

Initiated in 2006, the Solar Cities program is a $94 million Australian Government initiative that runs until 2013. Solar Cities is a partnership between all levels of government, industry, business and local communities to trial sustainable energy solutions.

In seven key locations, each Solar City is trialling a unique combination of solar power, solar hot water, smart meters, energy efficiency measures and cost-reflective pricing. The program will also showcase the economic and environmental benefits of wiser energy choices through large demonstration projects.

The sites selected for the Solar Cities program are Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth and Townsville. As at September 2009, all seven of these cities were offering products and services to the community.

Data collected from each of the trials will inform future policies and show how different approaches influence energy use. The Solar Cities trials are effectively set up as a field experiment, where one or more variables are manipulated in a natural setting. The range of Solar Cities measures are being trialled in real-world situations within homes and businesses. The collection of baseline data, the creation of control groups, and the collection of data from a range of participants in different circumstances, locations and conditions will ensure the data is externally valid.

Green Loans Program

In recognising that many households struggle to find the upfront cash needed to invest in solar, water and energy efficient technologies, the Australian Government introduced the Green Loans Program in July 2009. This innovative program is helping households reduce Australia's greenhouse gas emissions and water use and encouraging green-inspired investment with flow-on benefits to the small business sector. Green Loans has two main components:

- a free home sustainability assessment and report (valued at more than $250)
- access to interest-free finance through a subsidy provided to partnering financial institutions for loans of up to $10 000 to implement changes recommended in the assessment report.

The program's objectives are to:

- encourage wide-scale improvement of energy and water efficiency in the existing housing stock
- provide sound advice for up to 360 000 households on the most appropriate actions to reduce the environmental impact of operating their home
- provide financial assistance to an estimated 75 000 households to gain access to the resources they need to invest in energy- and water-efficient technologies

- reduce annual greenhouse gas emissions by around 0.33 Mt CO_2-e by 2020.

Energy Efficiency in Government Operations Policy

The Energy Efficiency in Government Operations Policy aims to reduce the energy consumption of Australian Government operations, with particular emphasis on building energy efficiency. It commits to a progressive improvement of overall agency energy performance through annual energy intensity reporting and minimum efficiency requirements. A comprehensive management framework incorporating Green Lease Schedules has been developed to ensure that Australian Government agencies can easily incorporate the required energy efficiency standards into their leases and other procurement activities. The policy is further supported by practical implementation tools, such as Green Lease Schedules and energy management plan templates, and an ongoing communications and education strategy.

The Australian Government is continuing to improve the environmental performance of its vehicle fleet. The target set in 2003—to increase the proportion of vehicles with scores in the top half of the Green Vehicle Guide from 18% to 28% by December 2005—has been exceeded. By June 2009, the leased fleet had achieved 51%.

The Australian Government fleet's environmental policy has now been refined to provide a greater focus on supporting the Australian automotive industry. By 2020, 50% of the fleet's passenger vehicles will be Australian made, deliver value for money and be environmentally friendly. By June 2009, about 19% of the Australian Government fleet passenger vehicles had achieved this outcome.

Reducing emissions from the transport sector

Green Car Innovation Fund

The Australian Government has established the Green Car Innovation Fund to enhance research, development and commercialisation of Australian technologies that significantly reduce the fuel consumption or greenhouse gas emissions of passenger motor vehicles. The fund was announced as part of the Australian Government's *A New Car Plan for a Greener Future*, and will provide $1.3 billion over 10 years from 2009. Grants are selectively allocated based on the innovative, technological, commercial and environmental merits of proposals, and eligibility is not restricted to particular technologies. All organisations and individuals are eligible, including firms in the automotive supply chain, research organisations and international firms, as long as the work supported by the fund is performed in Australia. Consortiums may also submit proposals.

Green Vehicle Guide

The Green Vehicle Guide website is a tool to assist consumers in making informed decisions regarding the environmental performance of new vehicles. It covers all light vehicles (up to 3.5 tonnes) released onto the Australian market since late 2004, and is regularly updated as new models are released. The Green Vehicle Guide provides consumers with user-friendly ratings on the environmental performance of specific models, addressing greenhouse emissions, air pollution emissions and overall environmental performance. The guide also provides data on fuel consumption and enables annual fuel costs to be estimated. It enables side-by-side comparisons of individual models on a common basis, as all the vehicles undergo the same standard emissions tests.

The Green Vehicle Guide is recognised as the definitive source for assessing the environmental performance of light vehicles in Australia, and is increasingly used by fleets, in both government and industry, to determine the environmental benchmarks in their purchasing criteria.

Vehicle fuel efficiency measures

In July 2009, the Council of Australian Governments considered the final report from the Australian Transport Council and the Environment Protection and Heritage Council on a package of vehicle fuel efficiency measures. Following consideration of the report, COAG requested a regulatory assessment be undertaken to assess the merits of CO_2 emissions standards for light vehicles, and also adopted a range of consumer information measures. The measures agreed by COAG are incorporated in the National Strategy on Energy Efficiency.

Fuel consumption label

Since 2001, all new cars, four-wheel drives and light commercial vehicles in Australia have been required to display a fuel consumption label at the point of sale. The label has been progressively improved to provide more useful comparative information on both fuel consumption and CO_2 emissions of different vehicle models. The information is based on a standardised test, which all new vehicle types undergo prior to their supply to the market.

A revised fuel consumption label was fully implemented in April 2009. The new label displays three fuel consumption numbers from the standard test—'combined', 'urban' and 'extra-urban'—as well as the combined CO_2 value. The new label is particularly valuable in highlighting the significantly higher fuel consumption rates that consumers can expect when driving in urban environments compared to highway operation.

The label is linked with the Green Vehicle Guide, and the fuel consumption and CO_2 data displayed on the label matches that which is provided through the guide.

Australian engagement on international transport emissions

Australia is working with other countries to develop goals and measures for reducing emissions from international aviation and shipping through the International Civil Aviation Organization and the International Maritime Organization. Effective action on international aviation and shipping emissions requires a concerted effort by all countries due to the integrated, global nature of these sectors. Australia supports practical solutions to address international transport emissions that are non-discriminatory, do not disproportionately affect long-distance operations, and do not introduce competitive distortions.

Reducing emissions from the land sector

Australia has higher emissions from the land sector than many other OECD countries, reflecting Australia's large land mass and extensive primary industries. Policies and measures in these sectors aim to address knowledge gaps and facilitate adoption of management options that provide for emissions reductions and other environmental and economic benefits for industries and communities. The central driver of Australia's mitigation effort is the CPRS, which will provide a price incentive for agricultural offsets and for the sequestration of carbon in forests.

National Carbon Accounting Toolbox

The Australian Government's National Carbon Accounting Toolbox enables individual land managers to estimate greenhouse gas emissions and removals produced through their land management actions. It is derived from the National Carbon Accounting System and allows production of site-specific estimates using the same modelling system and data the Australian Government uses to develop national greenhouse gas accounts from the land sector. The National Carbon Accounting Toolbox is currently available as a prototype. The Australian Government is investing $16.1 million over four years from 2009–10 to develop a new system, which will be operational for forestry before its voluntary coverage under the CPRS from July 2010. Preliminary development of an agriculture emissions estimation capability will also be undertaken.

Agriculture

Mitigation policy

The Australian Government has committed to exclude agriculture indefinitely from the CPRS. Given the contribution of the agriculture sector to Australia's national emissions (around 16%), it will be important for the sector to contribute to meeting Australia's emissions reduction targets. The Australian Government will continue to work with industry to monitor world's best practice in reducing agricultural emissions and consider a range of ways in which the agriculture sector can contribute to the transition to a low-pollution economy. The Australian Government has committed to conducting a review in 2015 of whether the sector is at world's best practice in mitigation and an examination of the potential measures to achieve this.

Under the CPRS, offset credits will be allowed for abatement from a range of agricultural sources counted towards Australia's international climate change obligations, subject to the development of robust methodologies. The Australian Government will also provide for offsets from sources that are not counted towards Australia's international commitments through the voluntary National Carbon Offset Standard (see page 71 for more information). A policy and legislative framework will be established that ensures that domestic offsets meet internationally accepted principles of permanence, additionality, measurability, avoidance of leakage, independent audit and registration.

Research and development

To assist farmers to take advantage of these expanded offset opportunities, the Australian Government will provide $50 million for research, development and on-farm testing of emissions reduction options, including biosequestration and livestock, supported by a voluntary reporting trial. This funding includes support for the development of the global alliance on agricultural mitigation research proposed by New Zealand.

The Australian Government will complement its funding of agricultural research and development

funding with a $40 million Green Carbon Fund to monitor and plan for the impact of climate change on biodiversity, and encourage environmental stewardship where there are carbon co-benefits.

The Australian Government has also committed to a five-year, $150 million stream as part of the Climate Change Action Fund (see 4.2.3) to assist food processors to reduce their liability under the CPRS through fuel substitution and wastewater management projects.

The Australian Government's Australia's Farming Future initiative aims to build adaptable and resilient producers and industries and strengthen their ability to manage the risks arising from climate change. The $46.2 million Climate Change Research Program under the initiative funds research and on-farm demonstration projects to help prepare Australia's primary industries for climate change and build resilience with practical management solutions for farmers and industries. Research includes understanding and managing emissions from soils and reducing emissions from livestock. Further information on Australia's Farming Future is provided in Chapter 6.

National Agriculture and Climate Change Action Plan 2006–2009

The National Agriculture and Climate Change Action Plan 2006–2009 is an agreement between the Australian Government and state and territory governments to develop a coordinated framework for climate change policy in agriculture to contribute to the development of a sustainable, competitive and profitable Australian agriculture sector into the future. A critical role of the plan is to steer policies and frameworks towards supporting risk management and sustainable practices by primary producers and promoting a culture of innovation and responsiveness to change to help deal with the business challenges that lie ahead.

The action plan provides a framework for climate change policy for government and the agriculture sector across four strategic focus areas: adaptation strategies for a changing climate; mitigation strategies to reduce greenhouse gas emissions; research and development; and communication to inform decision making by primary producers and rural communities.

Land use, land-use change and forestry

Mitigation policy

Australian deforestation emissions have reduced markedly since 1990, due in part to increased restrictions on land clearing for agricultural land uses.

To reduce Australia's deforestation emissions further, the CPRS will create incentives to encourage and protect forest regrowth on deforested land. Australian emissions units will also be provided for offset projects that avoid deforestation, subject to the development of appropriate methodologies.

National Climate Change and Commercial Forestry Action Plan 2009–2012

The National Climate Change and Commercial Forestry Action Plan 2009–2012 was developed in collaboration with key stakeholders to assist the forestry industry to respond to climate change through adaptation and mitigation, underpinned by research and development and communication.

The action plan covers the following sectors and activities:

- tree plantations developed for commercial purposes at all scales. This includes farm forestry, agroforestry, broad-scale plantations, and trees planted for a mixture of commercial and environmental purposes
- wood production from native forests (excluding all native forests that are not harvested, for example, national parks)
- processing facilities that rely on raw material from production forests, including sawmills, board plants, and pulp and paper mills.

The action plan identifies knowledge gaps in the area of forestry and climate change; pinpoints potential obstacles that industry may face in its efforts to respond to climate change; identifies areas that require attention (such as management, policy and research needs); and provides a series of actions classifying areas of work that are fundamental in the context of addressing the impacts of climate change.

Forest Industries Climate Change Research Fund

The Australian Government has committed $5 million to the Forest Industries Climate Change Research Fund, a new grants program designed to address major knowledge gaps about the impact of climate change on forestry and forest industries in Australia. The program focuses on issues identified in the National Climate Change and Commercial Forestry Action Plan.

The fund will assist the industry to better understand the implications of climate change and build industry capacity to adapt to predicted scenarios and capitalise on emerging mitigation opportunities. Industry, scientific and government organisations across

Australia were encouraged to apply for research grants. The funding guidelines stipulated that projects were to focus on informing industry in the following areas:

- adaptation—to enable industry to adapt to new circumstances
- mitigation—to enable industry to contribute to the national climate change mitigation effort
- bioenergy—to promote the development of sustainable forest-based bioenergy on a commercial scale
- inventory and data—to fill data gaps so that quantitative analyses on climate change responses can be undertaken in the future.

Indigenous policies in the land sector

The Australian Government has committed to facilitating the participation of Indigenous people in carbon markets. Indigenous people will have the opportunity to undertake CPRS forest projects or offset projects, such as using traditional fire management practices to reduce emissions from savanna burning. Indigenous people may also undertake projects to generate offsets under the National Carbon Offset Standard for sale in the voluntary market—for example, reducing feral animals or undertaking revegetation or forest regeneration.

The Australian Government is investing $10 million through Caring for our Country to provide opportunities for Indigenous participation in carbon markets. The majority of this funding is being invested in fire management projects in Australia's northern savannas and to help resolve the scientific and methodological issues necessary to enable savanna offsets to be included in the CPRS.

Offsetting activities

National Carbon Offset Standard

In November 2009, the Australian Government released the National Carbon Offset Standard (NCOS) to provide national consistency and consumer confidence in the voluntary carbon market. The new standard will take effect from 1 July 2010.

The NCOS provides guidance on what constitutes a genuine, additional voluntary offset. It also sets minimum requirements for the verification and retirement of voluntary carbon credits and provides guidance for calculating the carbon footprint of an organisation or product for the purpose of achieving 'carbon neutrality'.

Organisations seeking to achieve carbon neutrality will be able to purchase a range of eligible offset credits under the NCOS, including:

- carbon pollution permits, known as Australian emissions units, including those from forestry projects opting into the CPRS (and any other offsets allowed under the CPRS)
- Kyoto units recognised and accepted under the CPRS
- credits issued under the internationally recognised Gold Standard and Voluntary Carbon Standard (provided they meet specific requirements)
- credits issued from domestic offset projects that reduce emissions from sources not counted towards Australia's Kyoto Protocol target.

Domestic offset credits include offsets from grazing land and crop land management, including biosequestration through soil carbon and biochar, forest management (for forests established before 1990), and revegetation (establishment of woody biomass that does not meet forest criteria).

A logo will be made available so that consumers can have confidence that organisations and products bearing the logo have achieved carbon neutrality in a way that complements the CPRS and achieves genuine emissions reductions.

Greenhouse Friendly™

The Greenhouse Friendly™ program was designed to help meet the challenge of climate change by:

- providing businesses and consumers with the opportunity to sell and purchase greenhouse-neutral products and services
- broadening the basis for investment in additional greenhouse gas abatement
- engaging consumers on climate change issues.

Greenhouse Friendly™ has been an effective and successful avenue for participation in the voluntary carbon market in Australia.

The introduction of the CPRS has implications for the Greenhouse Friendly™ program. The broad coverage under the CPRS means that there is less scope to pursue offset activities as voluntary market offsets are limited to emissions sources not covered by the scheme.

For these reasons, Greenhouse Friendly™ will conclude on 1 July 2010. Its functions will be continued under the NCOS—which comes into effect on 1 July 2010—in a way that complements the CPRS.

Reducing emissions from the waste sector

The waste sector accounts for around 3% of Australia's emissions. Almost all waste emissions are from solid waste landfill facilities (around 13 Mt CO_2-e) and wastewater (around 3 Mt CO_2-e). Waste emissions also occur at a small number of dedicated waste incineration sites.

Solid waste emissions are mainly from decomposing organic material (such as food, paper, garden waste and wood) in landfill facilities. Wastewater emissions come from decomposing organic material at wastewater treatment facilities and from treated wastewater following its release into waterways. Many food processing and other industries also have on-site wastewater treatment facilities.

The CPRS will impose obligations on operators of large landfill, wastewater treatment and waste incineration facilities.

In general, the CPRS will cover landfill facilities that emit more than 25 000 tonnes of CO_2-e a year. To avoid waste displacement from covered to uncovered sites, a lower threshold of 10 000 tonnes of CO_2-e emissions will apply for sites operating in close proximity to one another (the proximity distance is yet to be determined).

Most emissions from landfill sites are the result of waste deposited in the past, often referred to as 'legacy' emissions. While these emissions will count toward CPRS thresholds, there will be no liability under the CPRS for legacy emissions. The CPRS will not cover landfill facilities that are already closed.

In November 2009, Australia's environment ministers, through the Environment Protection and Heritage Council, released the National Waste Policy: Less Waste, More Resources. The policy charts the vision for resource recovery and waste management to 2020. Developed with the support of industry and key non-government organisations, it provides for collaboration to deliver effective approaches to domestic waste issues. The policy aligns with Australia's international obligations and complements the Australian Government's climate change and sustainability policies.

The National Waste Policy contains a number of strategies to reduce greenhouse gas emissions from landfills through enhanced biodegradable (organic) resource recovery. For example, state and territory governments will continue to phase down the amount of organic material transported to landfill, including through beneficial re-use such as the use of alternative waste treatment technologies and waste-to-energy plants. Strategies for addressing and/or offsetting emissions from landfill that complement the approach to resource recovery from organic waste will also be developed.

Including the waste sector in the CPRS will create incentives for local authorities, households and businesses to reduce the amount of organic waste being sent to landfill. Coverage will also create incentives to capture methane from waste landfill sites before it is emitted to the atmosphere. This methane can be flared or used to generate renewable electricity, providing additional greenhouse benefits.

4.2.3 Transitional policies and measures

In addition to establishing a range of policies and measures to complement the CPRS and assist in reducing greenhouse gas emissions, Australia is implementing a series of transitional policies and measures. These policies and measures will assist the Australian community with the transition to a low-emissions economy, led by a fully functioning CPRS and a set of complementary measures.

These transitional policies and measures focus on motivating and supporting businesses, organisations and households to take action on climate change, by providing access to information and tools and promoting affordable opportunities to alter their practices and make necessary transitions. The transitional measures provide different sectors of the community with financial and educational incentives—for example, to develop more energy-efficient practices or invest in innovative projects that address the impacts of climate change.

Climate Change Action Fund

The Australian Government will establish the $2 billion Climate Change Action Fund to provide targeted assistance to businesses, community sector organisations, workers, regions and communities, helping to smooth the transition to a low-emissions economy. The fund will operate over seven years from 2009–10 to 2015–16.

The fund will assist:

- small to medium-sized enterprises and community sector organisations that may be impacted by the CPRS
- specific industries, workers, regions and communities that may experience a concentrated impact flowing from the implementation of the CPRS

- businesses that are not eligible for other forms of assistance associated with the CPRS, in recognition that there may be other situations where assistance is warranted.

The fund will have four streams of activity:

- information—the provision of information to businesses and community service organisations
- investment—grants and incentives for businesses and community service organisations to invest in energy efficiency projects and low-emissions technologies, processes and products
- structural adjustment—assistance in the event workers and communities are significantly impacted by the introduction of the CPRS
- coal sector adjustment—structural adjustment assistance for coalmines with high fugitive emissions which will be significantly impacted by the introduction of the CPRS.

Together, these measures will contribute to Australia's comprehensive climate change response, and help businesses and community organisations prepare for the CPRS.

The Climate Change Action Fund will support early action on energy efficiency, helping Australian businesses and community organisations to save on their energy bills and deliver significant low-cost emissions reductions.

Early action activities will include:

- a business information package to provide advice to businesses on how the CPRS will work and the impacts and opportunities that may arise
- energy efficiency strategies for business, including energy audits and investment and information programs
- capital investment grants for businesses and community organisations.

The Australian Government will also use a portion of the funding to assist community service sector organisations to identify energy efficiency opportunities that may arise through the introduction of the CPRS.

Clean Business Australia

Clean Business Australia is an Australian Government partnership with business and industry. Its three components provide grants to support a range of activities to improve energy and water efficiency and increase sustainability, with a focus on productivity and innovation.

The **Green Building Fund** aims to reduce the energy consumed in the operation of existing commercial office buildings and will provide grants through two streams of activity. Through stream A, owners of existing commercial buildings are supported to reduce their energy consumption by retrofitting and retro-commissioning of buildings through grants ranging from $50 000 to $500 000, for up to 50% of project costs. Stream B provides grants of up to $200 000, for up to 50% of project costs, to relevant industry associations to develop their knowledge and skills through projects that improve energy efficiency and reduce emissions.

The competitive **Climate Ready Program** provides $75 million over four years from 2008–09 to small and medium-sized companies for projects that address the impacts of climate change. Grants range from $50 000 to a maximum of $5 million and will fund up to 50% of eligible expenditure on approved projects.

The **Re-tooling for Climate Change** program helps small and medium-sized manufacturers reduce their environmental footprint, through projects that improve the energy and/or water efficiency of their production processes. The program provides grants of between $10 000 and $500 000, up to a maximum of 50% of project costs.

National GreenPower Accreditation Program

The National GreenPower Accreditation Program (GreenPower) is offered jointly by participating state and territory government agencies in New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory. GreenPower aims to facilitate the installation of new renewable energy generators across Australia, beyond mandatory renewable requirements.

Under the program, customers can elect to pay a premium to their energy retailers for the supply of electricity generated from accredited renewable sources. Accredited energy suppliers then agree to buy an amount of energy from renewable sources equivalent to the amount nominated by participating consumers and businesses.

The program has similar objectives to the Renewable Energy Target—that is, to reduce greenhouse gas emissions from the electricity generation sector and drive investment in renewable energy projects. However, while the RET is a legislated requirement,

GreenPower relies on the consumer to pay a premium voluntarily. GreenPower provided by retailers to meet customer demand cannot be 'double counted' to contribute to meeting their RET obligations.

Ongoing compliance of products is checked regularly via technical status reports provided by the energy suppliers. Independent audits are carried out by Industry and Investment New South Wales, as the national program manager. Participating state and territory governments promote and help energy suppliers to market GreenPower accredited products to increase participation and therefore demand for renewable energy. Several of the state governments also provide financial assistance for the development of new generators, and have policies for government bodies to purchase GreenPower.

4.3 Policies and measures at the state, territory and local levels

4.3.1 Policies and measures of states and territories

All state and territory governments supported the introduction of the Australian Government's CPRS. In December 2007, all states and territories agreed through COAG to complete reviews of their existing climate change programs, to create a coherent and streamlined set of climate change measures that are complementary to the CPRS, and to cease duplicative and less efficient programs. These reviews were to be conducted in accordance with the COAG-endorsed complementarity principles (see 4.2.2), which state that, to be complementary, each measure must be closely targeted at a market failure that is not expected to be adequately addressed by the CPRS.

The states and territories are expected to complete their reviews by the end of December 2009. Early indications of the outcomes of the reviews can be found in the published New South Wales and Queensland examples.

- The New South Wales Government review was released concurrent with the Government's response in July 2009. The review is available on the New South Wales Independent Pricing and Regulatory Tribunal website.
- The Queensland Government review was completed in February 2009 as part of its review of its climate change strategies, ClimateSmart 2050 and ClimateSmart Adaptation 2007–12. The results of the review were released in August 2009 as part of the launch of Queensland's revised climate change strategy, ClimateQ. The development of the new measures included in ClimateQ took the complementarity principles into account.

Most states and territories have developed or consolidated their policies and measures within an overarching long-term climate change strategy. Their strategies broadly encompass commitments to:

- facilitate energy efficiency
- reduce greenhouse gas emissions from government operations
- exchange best-practice policy and research
- provide limited assistance to developing countries.

For example, the Queensland Government's climate change strategy, ClimateQ, outlines long-term investments and policies to further reduce the state's greenhouse gas emissions, such as conditions on all new coal-fired power stations to use low-emissions technologies, a transport plan to reduce congestion with a high-technology traffic management system and strategies to identify the carbon potential of native vegetation.

The New South Wales Government currently administers an emissions trading scheme, the Greenhouse Gas Reduction Scheme (GGAS), which was developed to reduce greenhouse gas emissions associated with the production and use of electricity. New South Wales and the Australian Capital Territory will continue to participate in GGAS until the commencement of the CPRS, at which time GGAS will cease to operate. Other states have developed emissions offsets programs that offer incentives for the purchase of offsets, such as the Western Australian Government's emissions offset scheme for government vehicles.

As part of the **National Strategy on Energy Efficiency**, all state and territory governments have developed regulatory and voluntary energy efficiency and sustainability policies and measures, to improve energy, water and waste efficiency across a range of sectors including government, industry, community and households. Most states and territories have implemented sustainability and energy efficiency policies and measures that require new residential developments, as well as alterations and additions to existing buildings, to meet defined energy efficiency and water management standards as part of the national process to improve the energy efficiency of Australia's building stock.

As agreed under the strategy, state and territory governments have committed to improving energy efficiency in **government operations**, and many have set goals for achieving carbon-neutral operations. These commitments will be realised through measures such as purchasing minimum percentages of GreenPower for government operations and requiring all new government-owned office buildings to target a five-star energy performance standard, where practical. State and territory governments have also committed to introducing minimum emissions standards for government fleet vehicles and invested in research and development of alternative vehicle fuels, technologies and electric or hybrid cars. The Victorian Government, for example, has supported the manufacture of Toyota Hybrid Camrys through its commitment to purchase 2000 of these vehicles for its fleet.

State and territory governments are **supporting the uptake of energy efficiency by businesses and householders** by providing energy, water and waste efficiency information, energy audits and energy savings action plans. Some programs are specifically designed to assist low-income households and small businesses in remote communities to become more energy efficient. Many of these energy audit and assessment programs are complemented by rebate or refit programs to encourage the implementation of recommended energy efficiency improvements. Rebate initiatives are designed to offset the costs of buying or installing energy efficiency measures such as small-scale energy efficiency hardware, solar hot-water systems and insulation.

States and territories have stipulated **providers of electricity and gas** must contribute to energy efficiency measures to improve the energy efficiency of residential homes. In states such as New South Wales, Victoria and South Australia, this is achieved through programs that acquire and surrender energy efficiency certificates. Other states have placed conditions on electricity and gas retailers to install energy savings measures in residential homes through their operating licenses. The Victorian Government is also leading the roll-out of smart meters, which provide real-time information about electricity use to help householders and small business operators manage their energy use and reduce emissions.

Renewable energy generation targets set by state and territory governments have recently been absorbed within the Australian Government Renewable Energy Target. All of the states and territories participating in the national electricity market have **feed-in tariff schemes** for renewable energy generation that pay the owners of eligible renewable energy generation systems for the electricity they feed into the national electricity grid. Many also have programs aimed at supporting a range of generators including households, small business, schools, community organisations and small-scale commercial generators.

State and territory governments have developed policies and measures to expand their **renewable energy sectors**, such as the South Australian Government's renewable energy generation industry plan. To achieve renewable energy investment, states and territories offer grants and loans to support proven renewable energy technologies and to stimulate research and development and early commercialisation of new technologies that will generate electricity or displace grid electricity use. Some states are also implementing clean energy projects to change the way energy is supplied to remote communities, including exploring renewable energy options.

State and territory government investment in **research and development** extends beyond renewable energy to include funding for new technologies such as clean coal and carbon capture and storage technologies. Research programs have also been designed to demonstrate reductions in energy consumption and greenhouse gas emissions through co-generation in residential developments. Some states are also funding exploration of geological sites for long-term, safe and secure storage of carbon dioxide emissions.

State and territory governments are responsible for **road and transportation** service delivery and have developed public transport planning tools, infrastructure and facilities, and state-of-the-art transport systems to improve traffic flow to reduce emissions. They have designed policies and measures that encourage the use of smaller and cleaner vehicles, such as stamp duty concessions for low-emissions vehicles, and lower-emissions fuels.

Other complementary programs address policy needs relative to each state and territory's particular circumstance. The Northern Territory Government, for example, developed the West Arnhem Land Fire Abatement Project in partnership with traditional owners and Indigenous ranger groups to facilitate strategic fire management.

4.3.2 Policies and measures of local governments

The Australian Government has a number of initiatives that recognise and promote local

government leadership and participation in climate change initiatives. For example, one of the objectives of the Australian Government's $25 million Local Government Reform Fund is to support and showcase best-practice collaborative council projects that build local government capacity to plan for and adapt to climate change.

The Australian Government hosts the Australian Council of Local Government meeting annually. All Australian council mayors and shire presidents are invited to a forum with government leaders to discuss key issues affecting local governments and the communities they serve. Climate change adaptation and mitigation have been high-priority topics at these meetings since the inaugural forum was held in 2008. This forum will continue to be used to inform and advance the Australian Government's policy and support in relation to impacts on local government of climate change.

The Australian Government's National Awards for Local Government recognise, reward and promote the innovative work of local governments across Australia. The Leading Community Greenhouse Actions Award category recognises councils that have demonstrated leadership in raising community awareness of climate change and the opportunities to reduce emissions, and have undertaken innovative actions to promote energy efficiency and greenhouse gas reductions within their community.

In 2009, two councils shared the National Award for Leading Community Greenhouse Actions.

- Melbourne City Council received an award for its Eco-City Melbourne campaign, which is targeted at developing an eco-city with a high quality of life and a significantly reduced ecological footprint in 2020. People and organisations are encouraged to become change agents, reducing the environmental impact of visitors, residents and businesses through the enhanced management of buildings, transport, energy, water and waste.
- Newcastle City Council of New South Wales was recognised for its ClimateCam—International Test Laboratory project, through which the city established itself as an international testing ground for the application of sustainable technology and practices. As part of this project, for example, the council developed the ClimateCam group of action-based learning programs to show the community and businesses how to achieve sustainable reductions in energy and water consumption. By the end of 2009, Newcastle is set to meet its target of reducing the city's greenhouse gas emissions to the same level as they were in the year 2000.

Towong Shire Council in Victoria received the small council award for this category, for its Pure Towong Energy project, focused on renewable energy. As part of this project, the remote shire of 6000 people has made significant advances with solar electricity.

4.4 Policies and measures no longer in place

The Fourth National Communication described a range of climate change policies and measures that were facilitating the mitigation of greenhouse gas emissions. Following the recommendations of the strategic review of Australian Government climate change programs (see 4.1.6) the programs identified as non-complementary to the CPRS have been either terminated or discontinued after all allocated funds were expended. In some cases, some program elements have been absorbed by new programs. Many of the programs listed below are now reflected in comprehensive policy strategies such as the National Strategy on Energy Efficiency.

Policies and measures that were no longer in place by December 2009 include:

- Greenhouse Challenge Plus
- Low Emissions Technology and Abatement
- Low Emissions Technology Demonstration Fund
- Greenhouse Gas Abatement Program
- Solar Homes & Communities Plan
- Renewable Remote Power Generation Program
- Phase-Out Incandescent Light Bulbs
- Local Greenhouse Action
- Best practice management of SF_6
- Programs supporting environmental management systems
- Greenhouse Action in Regional Australia Program
- Action on Energy Efficiency
- Alternative Fuels Conversion Program
- National Average Fuel Consumption Target
- Sustainable Transport
- Renewable Energy Development Initiative
- Wind Energy Forecasting Capability Initiative
- The Ethanol Distribution Program.

Table 4.1 ***Policies and measures aimed at limiting and reducing greenhouse gas emissions in Australia***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
National Strategy on Energy Efficiency	A comprehensive suite of measures that will assist households and business transition to a low-carbon future, reduce impediments to the uptake of cost-effective energy efficiency, make buildings more energy efficient and foster government leadership in energy efficiency. Measures under NSEE include: • the National Energy Efficiency Skills Initiative • the Equipment Energy Efficiency (E3) Program • energy efficiency requirements for residential buildings • energy performance for residential buildings—mandatory disclosure • commercial buildings energy efficiency—mandatory disclosure • energy efficiency requirements for commercial buildings • Commercial Building Rating tools • Heating, Ventilation and Air Conditioning High Efficiency Systems Strategy • phase-out of inefficient incandescent lights • phase-out of greenhouse intensive water heaters • Minimum Energy Performance Standards (MEPS): air conditioners	CO_2 / CH_4 / N_2O	Various: regulatory, voluntary, economic, informational	July 2009—many elements previously initiated under other programs	Implemented	June 2020, or earlier if agreed by all parties	All jurisdictions	38

Table 4.1 ***(continued)***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
Expanded national Renewable Energy Target	The expanded national Renewable Energy Target (RET) scheme is designed to ensure that 20% of Australia's electricity supply comes from renewable energy sources by 2020.	N/A (the RET reduces emissions in the electricity sector—electricity generated from renewable energy sources reduces emissions that would have been created from non-renewable electricity generation)	Regulatory	The increased annual targets under the expanded RET scheme commence from 1 January 2010. Solar Credits under the RET scheme applied from 9 June 2009.	Planned; legislation to implement the RET scheme was passed by the Commonwealth Parliament on 20 August 2009. Some subordinate regulations are pending.	The RET scheme will conclude in 2030.	Administered by the Renewable Energy Regulator	35
Energy Efficiency Opportunities	Encourages large energy-using businesses to improve their energy efficiency by requiring businesses to identify, evaluate and report publicly on cost-effective energy savings opportunities.	CO_2	Regulatory	2006	Implemented	N/A	Australian Government	6
Greenhouse Challenge Plus	Greenhouse Challenge Plus assisted companies in reducing their greenhouse gas emissions by improving greenhouse gas management, improving emissions measurement and monitoring, and strengthening government/industry information sharing.	CO_2 / CH_4 / N_2O, HFCs	Voluntary	1995	Completed	1 July 2009	Australian Government and industry	4

Table 4.1 ***(continued)***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
Energy Efficient Homes Package, including the Home Insulation Program and the Solar Hot Water Rebate Program	• Install ceiling insulation worth up to $1200 for Australian householders, including owner-occupiers, landlords, and tenants of currently uninsulated homes or homes with very little ceiling insulation. • Reduce the cost of installing energy-saving hot water units in Australian households.	CO_2, CH_4, N_2O	Economic	September 2007 (Insulation) September 2006 (Solar Hot Water)	Implemented	30 June 2012 or when allocated funds are fully committed, whichever occurs first.	Australian Government	5
Environmental strategy for the motor industry	Aims to improve motor vehicles' efficiency to deliver a range of environmental benefits, including reducing greenhouse gas emissions from the transport subsector. This comprises the Green Vehicle Guide, Fuel Consumption Label, the Australian Government Fleet Target and the former National Average Fuel Consumption Target.	CO_2	Regulatory and voluntary	2005	Implemented	N/A	Australian Government	2
Greenhouse Friendly™	Greenhouse Friendly™ was designed to help meet the challenge of climate change by certifying carbon-neutral products and services and approving abatement credits for sale on the voluntary market.	CO_2, N_2O, CH_4, SF_6, HFCs, PFCs	Voluntary	2001	Implemented	1 July 2010	An Australian Government program with private industry participants	1
Solar Flagships	The program is intended to support construction and demonstration of large-scale solar power stations in Australia.	CO_2	Fiscal	2009 announced	Implemented	N/A	Australian Government	1

Table 4.1 ***(continued)***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
National Low Emissions Coal Initiative	The initiative accelerates the development and deployment of technologies that will reduce emissions from coal use.	CO_2	Fiscal	2008	Implemented	N/A	Australian Government/ industry and researchers	1
National GreenPower Accreditation Program	The National GreenPower Accreditation Program is offered through joint collaboration by participating state and territory government agencies in New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory. It aims to facilitate the installation of new renewable energy generators across Australia, beyond mandatory renewable requirements.	N/A (GreenPower reduces emissions in the electricity sector—electricity generated from renewable energy sources reduces emissions that would have been created from non-renewable electricity generation)	Voluntary	1997—no abatement included until 2005	Implemented	N/A	New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory	3
Greenhouse Gas Abatement Program (GGAP)	The Greenhouse Gas Abatement Program (GGAP) was a competitive grants program designed to reduce Australia's net greenhouse gas emissions by supporting activities that 1) are likely to result in substantial emissions reductions, or 2) offset greenhouse emissions.	CO_2 / CH_4 / N_2O, HFCs	Fiscal	2003	Completed	2009	Australian Government	1
Renewable Remote Power Generation Program	The program increases the uptake of renewable energy technology in remote areas of Australia that currently rely on fossil fuel for electricity generation.	CO_2	Voluntary	2000	Implemented	2011	Householders, utilities and communities	0

Table 4.1 ***(continued)***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
Solar Cities	• Demonstrate the environmental and economic effects of combining cost-reflective pricing with the widespread use of solar technology, energy efficiency and smart meters. • Identify barriers to energy efficiency, electricity demand management and the use of solar technology, among businesses and householders in different parts of Australia. • Test ways to deal with these barriers.	CO_2	Voluntary, economic and regulatory	2004	Implemented	30 June 2013	Australian Government in partnership with Origin Energy, Alice Springs Town Council, BP Solar, Zero Net Emissions Company, Moreland Energy Foundation, Western Power and Ergon Energy	0
Green Loans Program	Encourage wide-scale improvement of energy and water efficiency in the existing housing stock while providing sound advice to households on the most appropriate action that can be taken to improve energy efficiency.	CO_2	Voluntary and economic	1 July 2009	Implemented	N/A	Commonwealth	0
State and territory policies and measures with significant mitigation impacts								
Greenhouse Gas Reduction Scheme (GGAS)	Requires liable parties (electricity retailers and large electricity users who choose to participate) to meet mandatory annual targets for reducing or offsetting greenhouse gas emissions from the production of electricity that they supply or use.	CO_2	Regulatory	1 January 2003	Implemented	Upon commencement of the CPRS	New South Wales Government	8

Table 4.1 ***(continued)***

Name of policy or measure	Objective and/or activity affected	Greenhouse gas/es affected	Type of instrument	Date commenced	Status	Date concluded	Implementing entity or entities	Estimated contribution to mitigation impact in 2020 (Mt CO_2-e)[1]
Queensland Gas Scheme	Requirement for electricity retailers to source a minimum percentage of their electricity from eligible gas-fired electricity provided above a baseline production amount: the percentage to increase from 13% in 2008 and 2009, to 15% in 2010 and not more than 18% for any year after 2010.	CO_2, CH_4, N_2O	Regulatory	2000	Implemented	N/A	Queensland Government	7
State and territory waste measures	State and territory measures aimed at waste diversion, recycling and methane capture at landfill sites.	CH_4	Regulatory, voluntary	1990	Implemented	N/A	State and territory governments	19
NSW and Queensland land-use change legislation	Reduce land-use change emissions from clearing of native vegetation in New South Wales and Queensland.	CO_2	Regulatory	1997	Implemented	N/A	New South Wales and Queensland governments	18[2]
TOTAL								**147**

Notes

- Policies and measures included in this table are those that are currently included in Australia's emissions projections modelling.
- Projected abatement from some measures in this table include mitigation overlap with abatement projected to arise from other measures included in this table. Where possible this overlap has been identified and removed from the total abatement estimate.
- Unless shown otherwise, estimated mitigation figures for individual policies and measures have been rounded to the nearest whole number.
- Additional measures for which abatement estimates are not listed separately also contribute to the total.

1 With the introduction of the CPRS, abatement from specific policies and measures that operate in covered sectors will no longer be separately identifiable. Under the CPRS, these programs will not produce additional abatement to that of the cap in the scheme. They will, however, assist in lowering the cost of achieving the same abatement.

2 Preliminary estimate: this estimate includes only one year of deforestation data since implementation of the NSW Native Vegetation Regulation 2005; this is insufficient information from which to draw conclusions about the effectiveness of the NSW native vegetation reforms. Nor does this estimate reflect the full effect of the phase-out of broad-scale clearing in Queensland.

References

CofA (Commonwealth of Australia) 2007, *Report of the Task Group on Emissions Trading*, Canberra.

—— 2008a, *Australia's Low Pollution Future: The economics of climate change mitigation*, Canberra.

—— 2008b, *Carbon Pollution Reduction Scheme: Green Paper,* Canberra, July.

—— 2008c, *Carbon Pollution Reduction Scheme: Australia's low pollution future*, 2 vols, Canberra, December.

—— 2008d, *Strategic Review of Australian Government Climate Change Programs*, Canberra.

DCC (Department of Climate Change) 2008, *National Greenhouse and Energy Reporting Guidelines*, Canberra.

Garnaut, R 2008, *The Garnaut Climate Change Review: Final report*, Cambridge University Press, Melbourne.

IEA (International Energy Association) 2008, *New Energy Realities—WEO calls for global energy revolution despite economic crisis*, press release, London, 12 November 2008.

McLennan Magasanik Associates 2009, *Benefits and Costs of the Expanded Renewable Energy Target*, available at www.climatechange.gov.au.

National Emissions Trading Taskforce 2007, *Possible Design for a National Greenhouse Gas Emissions Trading Scheme: Final framework report on scheme design*, available at www.garnautreview.org.au.

World Business Council on Sustainable Development/ World Resources Institute 2004, *The Greenhouse Gas Protocol—A corporate accounting and reporting standard*, World Business Council on Sustainable Development/World Resources Institute.

CHAPTER 5

Projections

KEY DEVELOPMENTS

Australia remains on track to meet its Kyoto target (of 108% of 1990 levels), without the use of flexibility mechanisms or imported emissions permits. Incorporating lower rates of economic growth due to the global financial crisis, Australia's emissions on a Kyoto accounting basis are projected to reach an average of 581 Mt CO_2-e per year over the first commitment period (2008–12), which is 106% of 1990 levels.

On a UNFCCC accounting basis, Australia's emissions are projected to be 567 Mt CO_2-e per year on average over the Kyoto period, and 645 Mt CO_2-e in 2020.

Without the CPRS, baseline emissions are projected to continue to increase. In 2020, Australia's emissions are projected to be 669 Mt CO_2-e on a Kyoto accounting basis, equivalent to 121% of 2000 levels.

This chapter presents projections for Australia's greenhouse gas emissions. Projections are reported for each National Greenhouse Gas Inventory sector, focusing on 2010 and 2020. These sectoral projections were prepared in 2009. Projections of emissions presented here are in accordance with the UNFCCC guidelines for national communications for UNFCCC parties.

Emissions projections under Kyoto Protocol accounting rules are also reported, in order to track Australia's progress towards meeting its Kyoto target of limiting emissions over the first commitment period (2008–12) to 108% of 1990 levels (see Annex III).

The approach to preparing inventories and emissions projections under the Kyoto Protocol differs from the UNFCCC accounting approach in relation to land use, land-use change and forestry. Using the UNFCCC comprehensive definitions, the 1990 baseline is significantly lower than the level used for analysing progress towards Australia's Kyoto target. This difference in the accounting rules means that the emissions projections for UNFCCC accounting and for Kyoto accounting are different; as such projections are presented under both accounting treatments.

The following sections present a summary of Australia's approach to emissions projections, an assessment of the aggregate effects of policies and measures, and a discussion of the uncertainties associated with those projections. A sector-by-sector explanation of the projections is also provided, describing the approach adopted, key assumptions and results. The final section of this chapter describes Australia's emissions projections methodology in more detail. Details of the overall projections using Kyoto accounting rules are shown in Annex III.

5.1 Australia's approach to emissions projections

Australia produces a baseline emissions projection for each sector, reflecting the likely net level of emissions, including the impact of existing policies and measures. This corresponds to the UNFCCC 'with measures' scenario. A 'business as usual' projection of emissions is also produced, which corresponds to the UNFCCC 'without measures' scenario. 'Business as usual' refers to the level of emissions that would have occurred in the absence of specific policies and measures that reduce greenhouse gas emissions.

Further details on the full range of scenarios and updated projections will be presented in forthcoming Department of Climate Change publications.

Projections have been developed for the energy sector (stationary energy, transport and fugitive emissions sectors), and the agriculture, industrial processes, waste, and land use, land-use change and forestry sectors.

For some sectors, emissions projections are undertaken in-house by the Australian Government Department of Climate Change using publicly available data and data obtained from external consultants. For other sectors, emissions projections are provided by other government departments and external consultants. The projection process involves regular discussion between the consultants and the projections team on the data and methods employed. Sectoral emissions projections are also discussed and agreed by an inter-departmental committee.

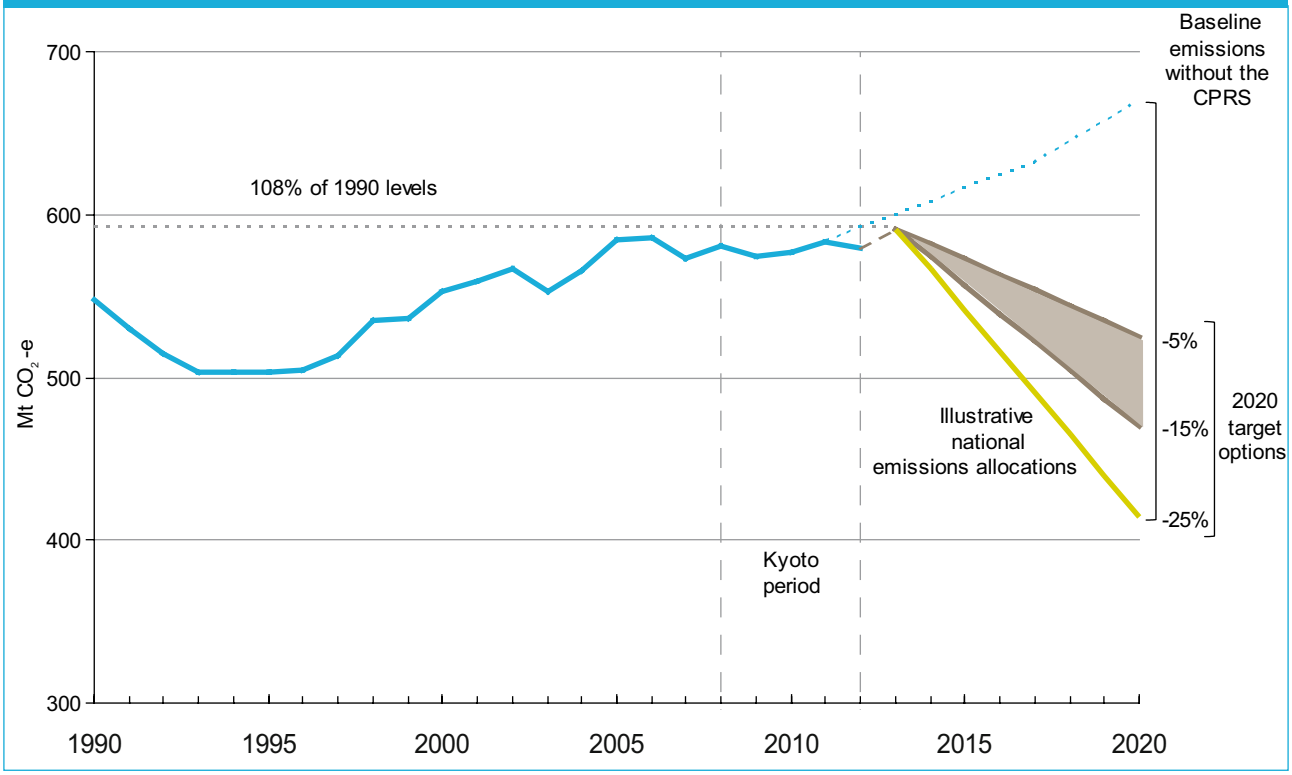
Sectoral emissions projections use a mix of top–down, computable general equilibrium models and bottom–up, sector-specific models. The 2007 National Greenhouse Gas Inventory (DCC 2009a) was used as a starting point for all sectors.

The Department of Climate Change has an ongoing program to update and improve sectoral projections. Areas of continuous improvement have included increased focus on the key drivers of sectoral projections, increased reconciliation of results from the different models within sectors and improvements to estimation of the impact of measures.

5.2 Summary of projections

Without the CPRS, baseline emissions are projected to continue to increase. In 2020, emissions are projected to be 669 Mt carbon dioxide equivalent (CO_2-e) on a Kyoto accounting basis, equivalent to 121% of 2000 levels (see Table 5.1). This provides a measure of Australia's 'abatement challenge'—the amount of additional abatement or avoided emissions required to achieve our 2020 target options. The abatement challenge under the minus 5% scenario is estimated to be 144 Mt CO_2-e in 2020. Under the minus 15% scenario the abatement challenge is estimated to be 199 Mt CO_2-e, while under the minus 25% scenario it is estimated to be 255 Mt CO_2-e. This is presented in Figure 5.1, which also shows illustrative 'straight line' reductions in emissions allocations from 2012 to the different 2020 target options.

Figure 5.1 Summary of Australia's emissions projections



Source: Unpublished Department of Climate Change analysis 2009.

Table 5.1 Summary of Australia's emissions projections, Mt CO_2-e (Kyoto accounting basis)

	2007	2020
Business as usual	631	816
Baseline (without the CPRS)	573	669
National emissions allocation[a]		
CPRS –5 target	573	525
CPRS –15 target	573	470
CPRS –25 target	573	415

Note: Columns may not add due to rounding.

a This represents Australia's international commitments or targets, akin to Australia's Assigned Amount under the Kyoto Protocol.

The baseline emissions projection is a 'with measures' scenario that incorporates all currently implemented and adopted policies and measures. This takes into account a projected 147 Mt CO_2-e of abatement from existing policies and measures in 2020, including at least 73 Mt CO_2-e from energy efficiency and renewable energy policies, and 18 Mt CO_2-e of abatement from policies restricting land-use change. Analysis indicates that these existing policies and measures are not capable of delivering significant further low-cost abatement, although some—such as energy efficiency measures—would be expected to deliver more abatement if reinforced by a broad-based incentive, such as the carbon price provided by the CPRS. Australia's 'business as usual' emissions are also projected, excluding all policies and measures to reduce emissions since 1990 (see Table 5.2).

Australia remains on track to meet its Kyoto target (of 108% of 1990 levels) on the basis of these projections, without the use of flexibility mechanisms or imported emissions permits. Australia's emissions on a Kyoto accounting basis are projected to reach an average of 581 Mt CO_2-e per year over the first commitment period (2008–12), which is 106% of 1990 levels.

The projection is also calculated on a UNFCCC accounting basis. On this basis, Australia's emissions are projected to be 567 Mt CO_2-e per year on average over the Kyoto period and 645 Mt CO_2-e in 2020.

On a Kyoto accounting basis and in the absence of all existing policies and measures, Australia's business-as-usual emissions are projected to be 656 Mt CO_2-e per year on average over the Kyoto period, or 120% of 1990 levels.

Table 5.2 Policies and measures included in the baseline projection

	2020 Mt CO_2-e
National Strategy on Energy Efficiency	38
Expanded Renewable Energy Target (RET)	35
State and territory waste measures	19
NSW and Qld land-use change legislation*	18
All other measures (including some energy efficiency measures)	37
Total measures	**147**

Notes: The baseline emissions case incorporates the currently implemented and adopted policies and measures summarised above. The business-as-usual emissions case excludes all policies and measures in this table.

With the introduction of the CPRS, abatement from specific policies and measures that operate in covered sectors may not be separately identifiable. Under the CPRS, these programs will not produce additional abatement to that of the caps in the scheme. They will, however, assist in lowering the cost of achieving the same abatement.

* Preliminary estimate; includes only one year of deforestation data since implementation of the NSW Native Vegetation Regulation 2005. This is insufficient information from which to draw conclusions about the effectiveness of the NSW native vegetation reforms.

The impact of all existing policies and measures is 74 Mt CO_2-e per year over the Kyoto period and 147 Mt CO_2-e in 2020. With the introduction of the CPRS, abatement from specific policies and measures that operate in covered sectors will no longer be separately identifiable. Under the CPRS, these programs will not produce additional abatement to that of the cap in the scheme. They will however, assist in lowering the cost of achieving the same abatement.

With the introduction of the CPRS, Australia's national emissions allocation in 2020 (including the purchase of international permits) is projected to decline to 525 Mt CO_2-e under the minus 5% scenario, 470 Mt CO_2-e under the minus 15% scenario, and 415 Mt CO_2-e under the minus 25% scenario.

The Australian Government has developed an emissions trading system—known as the Carbon Pollution Reduction Scheme, or CPRS—to be the primary mechanism for reducing Australia's greenhouse gas emissions.

The scheme is scheduled to commence on 1 July 2011. See 4.2.1 for more details of the CPRS.

This set of projections is consistent with the Australian Government's policy as stated here and as at 30 November 2009.

In the White Paper on the CPRS released in December 2008, the Australian Government decided on a medium-term target range to reduce emissions by between 5% and 15% below 2000 levels by 2020, taking into consideration the need to make a strong contribution to international efforts while ensuring a balanced and measured start to the scheme (CofA 2008b).

In May 2009, the Government committed to reducing national emissions to 25% below 2000 levels by 2020, in the context of a comprehensive global agreement capable of stabilising atmospheric concentrations of greenhouse gases at 450 parts per million (ppm) CO_2-e or lower. If it is not possible to secure international agreement to such ambitious action, the government will adopt a 2020 emissions reduction target within the original target range of minus 5% to 15%.

The Government has also committed to a long-term goal of reducing Australia's greenhouse gas emissions to 60% below 2000 levels by 2050, and to taking on a more ambitious 2050 target if the conditions for its 25% target are met, or if this is required to ensure Australia plays its full and fair part in international action.

The Government announced in May 2009 that obligations under the scheme would be phased in from 1 July 2011. Permits will cost a fixed price of $10 per tonne for the first year, 2011–12, with full market trading commencing on 1 July 2012.

To assist the transition to a lower-carbon economy, the Government announced in the CPRS White Paper a national emissions trajectory that establishes the pathway towards the 2020 target range. The national emissions trajectory will be used to set the caps on emissions in sectors covered by the scheme from 1 July 2012. Like Australia's Kyoto target, the indicative national trajectory and 2020 targets are defined in terms of 'national emissions', akin to Australia's national emissions allocation. National emissions are equal to actual 'domestic emissions' adjusted for international trade in permits. Permits may be banked within the scheme, so where permits are held over for use in a future year national emissions may be below the national emissions allocation.

The design of the CPRS, particularly its allowance of unlimited trade in recognised international permits between countries, means that the scale and pace of domestic abatement will be largely driven by the global carbon price, as the Australian carbon price is

expected to move relatively quickly to align with the international price trajectory.

The Government announced in the White Paper that emissions from the energy (covering stationary energy, transport and fugitive emissions from fuels), industrial processes and non-legacy waste sectors would be covered under the scheme from July 2011. Emissions from forestry (reforestation) would be included on a voluntary basis from July 2010.

The Government has since announced that agriculture will be excluded from the CPRS indefinitely and an agricultural offsets scheme developed.

Emissions from legacy waste, decommissioned mines, the existing stock of synthetic gases and land-use change (deforestation) will also not be included in the CPRS.

The design of the CPRS cap-setting process means that caps are automatically adjusted to achieve Australia's emissions reduction targets, given projected emissions from uncovered sources.

5.3 Baseline projections in detail

Under UNFCCC accounting rules, Australia's total emissions are projected to be 565 Mt CO_2-e in 2010 and 645 Mt CO_2-e in 2020 (see Table 5.3), with all sectors and greenhouse gas abatement measures included.

Australia is also on track to meet its Kyoto target. Using Kyoto accounting, the projections indicate that between 2008 and 2012, emissions would be 106% of 1990 levels on average. Details of the overall Kyoto projections are shown in Annex III.

Measures that are currently being implemented combine to deliver 74 Mt CO_2-e of abatement in 2010 and 147 Mt CO_2-e of abatement in 2020, across all UNFCCC sectors (energy, industrial processes, agriculture, waste, land use, land-use change and forestry).

5.3.1 Main sectoral contributions

Sectoral contributions to total emissions are dominated by energy, agriculture and land use, land-use change and forestry.

- The energy sector (composed of the stationary energy, transport and fugitive emissions sectors) continues to be the most significant source of greenhouse gas emissions (approximately 73% of total emissions in both 2010 and 2020).
- Industrial process emissions are expected to grow rapidly from a relatively small base. They will contribute approximately 6% of projected emissions in both 2010 and 2020.
- Agricultural emissions are not projected to grow significantly, but will still contribute approximately 15% of emissions in both 2010 and 2020.
- The contribution of the waste sector will shrink slightly and contribute approximately 3% of emissions in 2010 and 2% of emissions in 2020.
- On a UNFCCC accounting basis, emissions from the land use, land-use change and forestry sector are projected to be 16 Mt CO_2-e in 2010. The sector is estimated to have emitted approximately 38 Mt CO_2-e in 1990.

***Table 5.3** Net baseline greenhouse gas emissions projections (Mt CO_2-e), 1990 to 2020 (UNFCCC accounting method)*

	1990	2000	2010	2015	2020
Energy	286	359	413	441	478
Stationary energy	*195*	*251*	*293*	*306*	*322*
Transport	*62*	*75*	*81*	*89*	*95*
Fugitive	*29*	*33*	*39*	*46*	*61*
Industrial processes	24	26	33	35	37
Agriculture	87	95	88	94	97
Waste	19	16	15	15	15
Land use, land-use change and forestry	38	–90	16	7	17
Total	**454**	**404**	**565**	**593**	**645**

5.3.2 Reconciliation with the previous projection

The projections included in Australia's Fourth National Communication projected an 8% increase in emissions between 1990 and 2010 using Kyoto accounting rules and an 11% increase using UNFCCC accounting rules (Australian Greenhouse Office 2005).

Since the Fourth National Communication, updated sectoral projections together with the impact of measures reveal that Australia remains on track to meet its Kyoto target of limiting emissions to 108% of 1990 levels.

Emissions from the Fourth National Communication and this communication on a UNFCCC accounting basis are shown in Table 5.4.

Table 5.4 Comparison of Fourth National Communication and current projections (Mt CO_2-e) (UNFCCC accounting method)

Projection	1990	2010		2020	
		Business as usual	Baseline	Business as usual	Baseline
Fourth National Communication	511	649	565	766	647
Current projection	454	651	565	816	645

5.4 Baseline projections by sector

This section discusses the baseline projections for each sector, together with the business-as-usual projection and the impact of measures.

5.4.1 Projections of the energy sector (stationary energy)

Stationary energy includes emissions from the generation of electricity and from direct combustion of solid, liquid, gaseous, biomass and other fuels for purposes other than electricity generation. Electricity generation is the most significant contributor to emissions from this sector.

Factors influencing sectoral emissions projections

Growth in emissions from this sector is attributable to a range of factors, including energy demand. Energy demand is influenced by income growth and changes in:

- gross domestic product (GDP)
- population growth
- sectoral activity and structural change
- major resource projects
- ongoing improvements in energy efficiency
- changes in the fuel mix, including greater use of less carbon-intensive fuels such as natural gas and renewable energy.

Analytical approach followed

The stationary energy projection uses a combination of top–down and bottom–up economic models. The projection for the stationary energy sector was modelled using both an economy-wide general equilibrium approach, and more detailed bottom–up analysis, where individual electricity generators and energy-intensive projects could be specified. The models were provided by McLennan Magasanik Associates in conjunction with analysis from the Australian Treasury.

Assumptions

The assumptions used for the stationary energy projection are shown in Table 5.5.

Table 5.5 Summary of key modelling assumptions, stationary energy

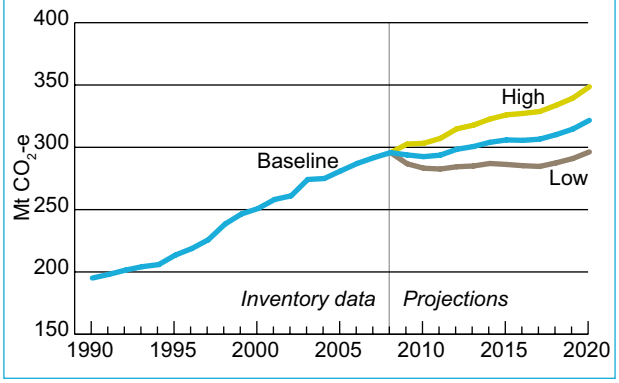
Variable	Unit	2010–20
Real gross domestic product	Annual % growth	1.5 to 4.0
Population	Average annual % growth	1.7
End-use energy efficiency	Average annual % improvement	0.6

Baseline projections

Emissions from the stationary energy sector in 2010 are projected to be 293 Mt CO_2-e, representing a 50% increase over 1990 levels. For 2020 the baseline projection is 322 Mt CO_2-e, an increase of 65% over 1990 levels.

Figure 5.2 shows historical and projected emissions from this sector.

***Figure 5.2** Emissions from the stationary energy sector (Mt CO_2-e), 1990 to 2020*



Effects of policies and measures already in place

The impact of existing measures in the stationary energy sector in 2010 is projected to be 34 Mt CO_2-e and is projected to increase to 98 Mt CO_2-e in 2020. The most significant measures in the stationary energy sector include the 20% Renewable Energy Target and the National Strategy on Energy Efficiency. For a full list of policies and measures, see Chapter 4.

5.4.2 Projections of the energy sector (transport)

Greenhouse gas emissions from the transport sector include emissions from the direct combustion (or end use) of fuels by road, rail, domestic air transport and domestic shipping, but do not include full fuel cycle emissions. Road transport is by far the most significant source of transport emissions. Passenger motor vehicles together with trucks and light commercial vehicles have been responsible for the majority of the growth in transport emissions.

Factors influencing sectoral emissions projections

Transport sector emissions are driven primarily by economic activity, population growth and oil prices. Other significant factors include improvements in vehicle technology, such as fuel efficiency and design standards; changes in the travel behaviour of individuals in response to trends in personal incomes; and the impact of greenhouse gas abatement measures introduced by governments.

Emissions from commercial vehicles are closely linked to demand for the goods and services they provide, which in turn are linked to the general level of growth in the broader economy. Economic growth and increasing per capita income levels also drive emissions from passenger cars, although not as directly as emissions from commercial vehicles and other modes of freight.

Analytical approach followed

The projection was initially undertaken for the Department of Climate Change by the Bureau of Infrastructure, Transport and Regional Economics using bottom–up modelling in late 2008, in the context of preparing the CPRS White Paper. The projection has been updated to incorporate preliminary 2008 and 2009 emissions levels taken from the National Greenhouse Gas Inventory.

The transport sector projection has been updated to reflect revised economic activity levels (CofA 2009). As a result, small upward adjustments have been made to projected emissions across the transport modes for the years 2010 to 2012. The Kyoto period projection has also been updated to incorporate the latest short-term oil price assumption from the US Energy Information Administration (2009b).

Assumptions

The transport sector emissions projections are highly dependent on a number of key forecast variables, including:

- economic and demographic indicators, such as GDP, international oil prices (see Table 5.6), consumption, income and population forecasts
- vehicle technology, such as fuel efficiency and design standards
- travel behaviour of individuals and firms
- the impact of greenhouse gas abatement measures introduced by governments.

***Table 5.6** Oil price assumptions*

	US$/barrel		
	2010	2015	2020
Oil price	75	63	57

Sources: US Energy Information Administration 2008 and 2009.

Note: Recent medium- to long-term oil price projections are generally higher than those used here. This analysis retains previous assumptions to maintain consistency with the Treasury report (CofA 2008a).

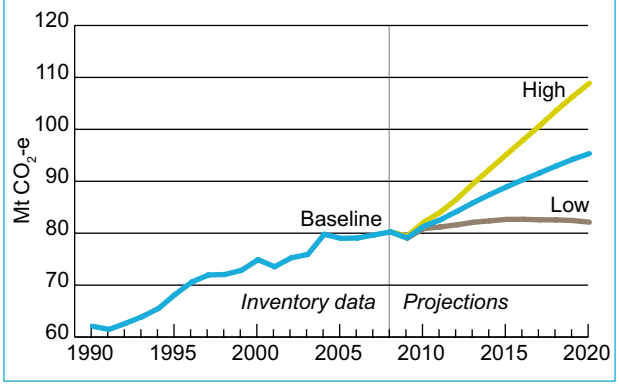
Baseline projections

Emissions from the transport sector in 2010 are projected to be 81 Mt CO_2-e. This represents a 31% increase over 1990 levels. Baseline emissions for 2020 are projected to be 95 Mt CO_2-e, which is an increase of 54% over 1990 levels.

Passenger cars account for more than half of all transport sector emissions; in 2007 they accounted for 53%. Commercial vehicles are the next largest contributor, accounting for over a third of emissions in 2007. Aviation, rail and shipping emissions account for the remainder.

Figure 5.3 shows historical and projected emissions from this sector.

Figure 5.3 Emissions from the transport sector (Mt CO_2-e), 1990 to 2020



Effects of policies and measures already in place

The impact of measures in 2010 in the transport sector is estimated to be 2 Mt CO_2-e, increasing to 5 Mt CO_2-e in 2020.

5.4.3 Projections of the energy sector (fugitive emissions)

The fugitive emissions sector covers methane, carbon dioxide and nitrous oxide emissions from the production, processing, transport, storage, transmission and distribution of fossil fuels. It also includes emissions from decommissioned ('abandoned') underground coalmines, incorporating flooding effects.

The fugitive sector emissions projection represents an update of the coal subsector by the Department of Climate Change, together with an update of the oil and gas subsector undertaken in 2009 by engineering consultants pitt&sherry.

Factors influencing sectoral emissions projections

The two key components of the fugitive emissions from the fuels sector are emissions from coalmines and from major oil and gas projects. Fugitive emissions are determined in part by the total production of coal, oil and natural gas, but more importantly by the emissions intensity of that production. For example, underground mining of coal from class A gassy mines generated around 58% of the coal fugitive emissions in 2007 (including post-mining emissions and emissions from decommissioned mines), but constituted less than 13% of all black coal mined. Similarly, the carbon dioxide content of natural gas deposits varies widely among different fields and is a significant driver of emissions from natural gas projects.

Production levels are driven by both domestic demand and export demand, which are in turn influenced by factors such as domestic and world economic growth, relative fuel prices and fuel substitutability in the various end-use markets.

Analytical approach followed

Fugitive emissions projections were prepared using bottom–up modelling approaches closely based on the methodologies used to compile the 2007 National Greenhouse Gas Inventory estimates for the sector.

The coal update was based on the latest inventory data on mine-specific emissions factors, together with updated projections of coal production based on commodity forecasts by the Australian Bureau of Agricultural and Resource Economics (2009a, 2009b) and mine-specific data provided by Wood Mackenzie Ltd (2009).

Emissions from oil and gas projects were estimated using a bottom–up approach by pitt&sherry. Most emissions are associated with either the extraction of oil and gas, or leakage from gas distribution systems. The main source of emissions data for these activities is the annual survey conducted by the Australian Petroleum Production and Exploration Association. These data were supplemented by data from a variety of other sources for those emissions unrelated to oil and gas production, including gas transmission, gas distribution and oil refinery flaring.

Assumptions

The fugitive emissions projection is heavily driven by assumptions about coal, oil and gas projects, particularly emissions-intensive class A gassy

coalmines and major liquefied natural gas (LNG) projects.

Methane emissions also occur following closure and abandonment of underground coalmines, leaking through fractured rock strata and open vents. The Australian methodology to quantify and project these emissions from decommissioned mines is based on the approach developed by the Intergovernmental Panel on Climate Change (2006).

Brown coal fugitive emissions were not projected, as the amounts are very small compared with emissions from black coal, and brown coal production forecasts are not available.

In the oil and gas subsector the largest source of fugitive emissions is venting of CO_2. This occurs in the course of acid gas stripping and is released together with small quantities of methane, entrained with the CO_2 in the stripping process. Acid gas stripping to remove CO_2 is undertaken when the proportion of CO_2 in raw gas exceeds the specified maximum for product gas, a maximum dependent on whether the product is pipeline gas or LNG. The projections analysis assumed that the maximum CO_2 concentration for pipeline gas is 2.5% by volume (mole %) and the maximum allowable concentration for gas to be liquefied is 0.2% by volume. The practical effect is that many fields producing pipeline gas do not require acid gas stripping, whereas it is always required for LNG production.

Historic values for the ratio of methane to CO_2 in the vented gas were calculated from the detailed industry emissions inventories produced by the Australian Petroleum Production and Exploration Association. These revealed a significant reduction in this ratio over the last few years. The analysis assumed further gradual reductions in the ratio for existing projects, reflecting incremental technical improvements. New plants were assumed to have a significantly lower ratio than existing plants.

A number of potential LNG projects based on coal-seam methane have not been included, because coal-seam methane has an intrinsically low CO_2 content and so these projects, if built, will not have a material effect on fugitive emissions.

The key production forecasts used for the baseline scenario are outlined in Table 5.7.

Table 5.7 Projection of fossil fuel production 1990 to 2020, baseline scenario

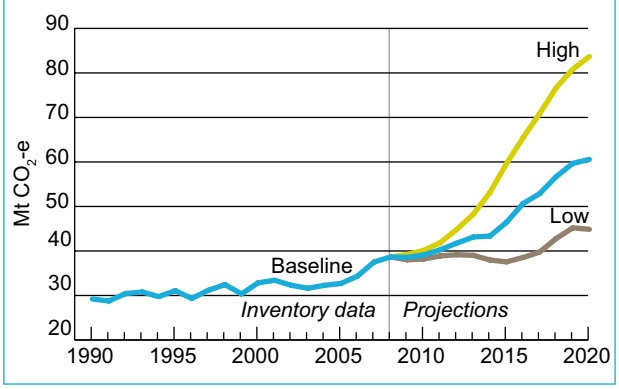
Fossil fuel	1990	2007	2010	2020
Black coal (Mt raw coal)	194	414	462	632
Oil and gas (PJ)	2081	3007	4044	7900

Baseline projections

Emissions from the fugitive emissions sector in 2010 are projected to be 39 Mt CO_2-e. This represents a 34% increase on 1990 levels. Baseline emissions for 2020 are projected to be 61 Mt CO_2-e, which is an increase of 107% over 1990 levels.

Figure 5.4 shows historical and projected emissions from this sector.

Figure 5.4 Baseline fugitive emissions from the fuels sector (Mt CO_2-e), 1990 to 2020



Effects of policies and measures already in place

The impact of existing measures is estimated to be 7 Mt CO_2-e in 2010 and 5 Mt CO_2-e in 2020. Existing measures are the Greenhouse Challenge Program and the Greenhouse Gas Abatement Program. While these programs have since finished, some abatement actions funded under these programs continue to achieve emissions reductions.

5.4.4 Projections of the industrial processes sector

The industrial processes sector includes process greenhouse gas emissions from the following subsectors:

- mineral products
- chemical industries
- metals production

- industries that use gases covered by the Montreal Protocol on substances that deplete the ozone layer
- sulphur hexafluoride (SF_6) used in electrical circuit breakers and switchgear.

Non-process greenhouse gas emissions and abatement from these industries are counted in other sectors in accordance with the definitions used in the National Greenhouse Gas Inventory.

Factors influencing industrial process emissions projections

Greenhouse gas emissions from industrial processes are the by-products of materials and reactions used in the production process.

In the mineral products, chemical and metals subsectors, production levels of the relevant product largely influence annual fluctuations in resulting emissions. Over time, technological change in production processes can have a significant impact on process emissions. For example, improved process monitoring and control has resulted in a substantial reduction in PFC emissions from aluminium smelting. Nonetheless, in these subsectors the chemistry of the processes involved places a physical limit on emissions reductions. Once minimum greenhouse emissions intensity is achieved, further reductions in emissions factors can occur only through technological changes that fundamentally alter the chemistry of the production processes. Major changes of this type are infrequent and difficult to predict.

In the Montreal Protocol and electricity supply industries, emissions are associated with leakages from equipment charged with synthetic greenhouse gases. Emissions in these subsectors are increasing rapidly from a low base as HFCs replace ozone-depleting substances, whose use is controlled by the Montreal Protocol. The key drivers of emissions in these subsectors include:

- growth in demand for products and equipment that require synthetic gases in operation (such as air-conditioning units and electrical switchgear)
- the amount of gas leakage occurring from those products.

Emissions from these industries can be reduced through improved sealing, handling and maintenance of equipment.

Analytical approach followed

The projection for the industrial processes sector were prepared by the Department of Climate Change using an in-house model. The model is consistent with the methodology used for the National Greenhouse Gas Inventory.

Assumptions

Industrial process emissions projections are heavily dependent on key commodity production forecasts, namely:

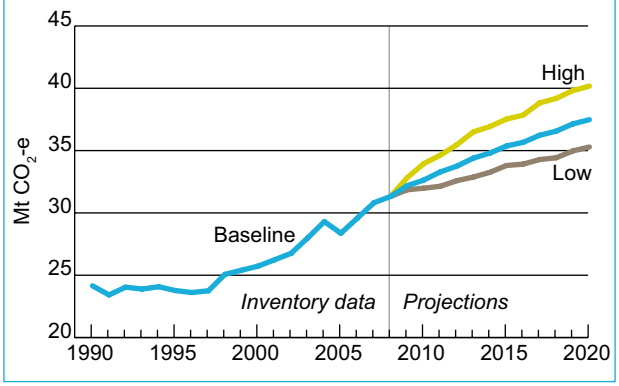
- aluminium
- iron and steel
- cement
- limestone.

Baseline projections

Emissions from the industrial processes sector in 2010 are projected to be 33 Mt CO_2-e. This represents a 35% increase on 1990 levels. Baseline emissions for 2020 are projected to be 38 Mt CO_2-e, which is an increase of 55% on 1990 levels.

Figure 5.5 shows historical and projected emissions from this sector.

Figure 5.5 Emissions from the industrial processes sector (Mt CO_2-e), 1990 to 2020



Effects of policies and measures already in place

The impact of measures is estimated to be 3 Mt CO_2-e in 2010, declining to zero in 2020, due to the conclusion of Greenhouse Challenge Plus.

5.4.5 Projections of the agriculture sector

Sources of greenhouse gas emissions from the agriculture sector under the UNFCCC classification of agriculture include non-CO_2 gases from livestock enteric fermentation, manure management, rice

cultivation, agricultural soils, burning of savannas and field burning of agricultural residues. Livestock is the primary source of agricultural emissions representing about 70% of agricultural emissions.

Factors influencing sectoral emissions projections

The key drivers impacting on agricultural emissions projections are the size of the beef herd, which is largely driven by export demand, and climate conditions such as prolonged drought.

Analytical approach followed

The projection of livestock and cropping emissions was undertaken for the Department of Climate Change by the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Centre for International Economics (CIE) in late 2008, in the context of preparing the 2008 Carbon Pollution Reduction Scheme White Paper. Base-level emissions for 2008 were taken from the 2007 National Greenhouse Gas Inventory, with the average of the ABARE and CIE projections forming an updated projection of agricultural emissions. Emissions from transport fuel and electricity used in agricultural enterprises are included in the transport and stationary energy sector projections.

ABARE and CIE undertook projections using bottom–up models linked with international markets, including market conditions and economic growth for Australia's major trading partners. The projection of savanna burning was estimated separately by the Department of Climate Change.

Savanna emissions arise from deliberate ignition by land managers or from wildfires. The largest areas burnt are in the Northern Territory, Western Australia and Queensland. The resulting emissions depend on a number of factors, including the area under fire management, the mass of fuel available from the previous season's growth, climatic conditions such as temperature and rainfall, and the timing of fires in the dry season. Of these factors, the most important driver appears to arise from the relationship between rainfall and the accumulation of fuel loads. It is difficult to project savanna burning emissions based on rainfall because reliable long-term rainfall projections are not readily available. Research work going on at present under the Caring for our Country program is expected to assist these measurement issues.

Assumptions

The most important assumptions in the agriculture projection are the levels of demand projected in key export markets for Australian agricultural commodities. Table 5.8 details the values for these key variables assumed by each of the sectoral models (ABARE and CIE).

Table 5.8 Key assumptions for the agriculture sector, 2004 to 2020

Assumption	ABARE	CIE
Rest-of-world GDP growth (%)	4.1	2.2 to 7.5
Rest-of-world population growth (%)	na	–0.2 to 1.5
Exchange rate (2010) ($US/$A)	na	1.43
Carcass weight (% improvement)	0.2	1

Note: CIE modelling contains estimates for 21 of Australia's major trading partners. The range presented here indicates the span of these forecasts.

Table 5.9 Projected total cattle numbers (million head)

Modeller	2010	2020
ABARE	28.6	30.2
CIE	29.0	32.6

Baseline projections

Emissions from the agriculture sector in 2010 are projected to be 88 Mt CO_2-e. This represents a 2% increase on 1990 levels. Baseline emissions for 2020 are projected to be 97 Mt CO_2-e, which is an increase of 12% on 1990 levels.

Figure 5.6 and Figure 5.7 show historical and projected emissions from this sector.

Figure 5.6 Emissions from the agriculture sector (Mt CO_2-e), 1990 to 2020, excluding savanna burning

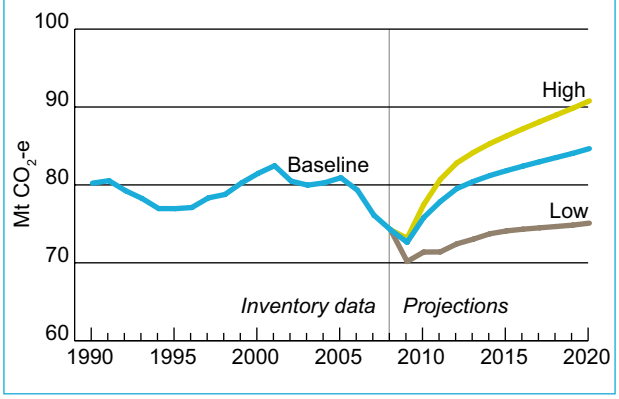
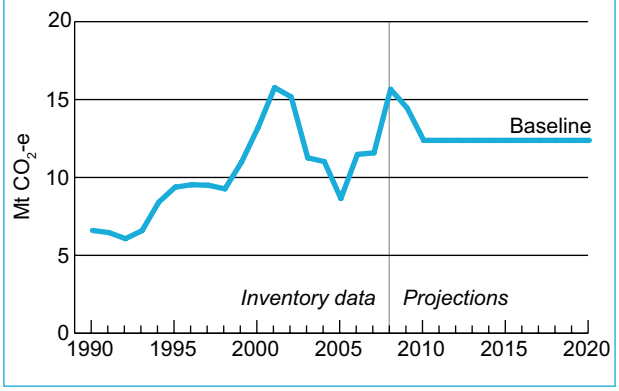


Figure 5.7 Emissions from savanna burning (Mt CO_2-e), 1990 to 2020



Effects of policies and measures already in place

The impact of measures in 2010 is estimated to be 0.6 Mt CO_2-e and is projected to rise to 1.1 Mt CO_2-e by 2020.

5.4.6 Projections of the waste sector

The waste sector includes emissions from the disposal of organic materials to landfill and wastewater emissions including domestic, commercial and industrial wastewater. Emissions are predominately methane-generated from anaerobic decomposition of organic matter. The primary greenhouse gas emitted is methane; carbon dioxide and nitrous oxide are also emitted.

Factors influencing sectoral emissions projections

The waste sector projection is based on two subsector projections, solid waste and wastewater. The main factors influencing the solid waste subsector are population growth and amount of waste produced per capita, whereas the main factors in the wastewater subsector are population growth and the proportion of population sewered. Improvements in landfill management and waste recovery management are projected to significantly reduce emissions from the sector.

Analytical approach followed

The projection for the waste sector was prepared by the Department of Climate Change using an in-house model, consistent with the methodology used for the National Greenhouse Gas Inventory. This methodology for estimating waste sector emissions has been modified since the Fourth National Communication projection; in particular, the mix of products disposed to landfill in Australia has been independently reviewed and revised, in response to recommendations of the UNFCCC expert review team report on Australia's initial report (UNFCCC 2009).

The review team recommended that the estimates of the volumes of wood and paper disposed to landfill, previously derived using the harvested wood products model developed by Jaakko Pöyry (2000), should be validated with reference to the available literature. In response to the review team's recommendation, the Department of Climate Change engaged two independent consultants (GHD and Hyder Consulting) to conduct a review of the available literature on the mix of products disposed to landfill in Australia. The final mix of waste disposed to landfill is based on the results of this research.

In aggregate, these changes resulted in a small increase in the 1990 estimate and a small decrease in the 2006 estimate. The projected mix of waste to landfill has also been revised in line with the inventory data and has led to a smaller projected decline in emissions. Population forecasts have also been revised since the last projection. This has resulted in a slightly higher projection by 2020.

Assumptions

The waste sector emissions projections rely on assumptions of population growth, the amount of waste produced per capita and the proportion of population sewered.

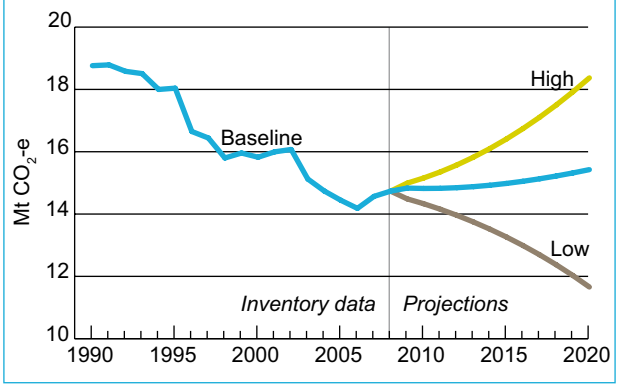
Best, low and high estimates of the growth of waste per capita are based on the historical data available from the National Greenhouse Gas Inventory.

Baseline projections

Emissions from the waste sector in 2010 are projected to be 15 Mt CO_2-e. This represents a 21% decrease on 1990 levels. Baseline emissions for 2020 are projected to be 15 Mt CO_2-e, which is a decrease of 18% on 1990 levels.

Figure 5.8 shows historical and projected emissions from this sector.

Figure 5.8 Emissions from the waste sector (Mt CO_2-e), 1990 to 2020



Effects of policies and measures already in place

The impact of measures is estimated to be 10 Mt CO_2-e in 2010 and is projected to increase to 19 Mt CO_2-e in 2020. The waste sector measures reflect the expected impacts of state and territory policies on waste management, including their performance against meeting waste diversion and landfill gas capture targets.

5.4.7 Projections of the land use, land-use change and forestry sector

Projections for the land use, land-use change and forestry (LULUCF) sector are completed for forest lands, croplands, grasslands and other categories.

Projections are presented only for the total LULUCF sector. The projections provided in this section are in accordance with the UNFCCC inventory reporting guidelines and are not consistent with the accounting provisions under the Kyoto Protocol.

Under the UNFCCC definitions, forestry is counted as a sink in 1990, whereas under Kyoto accounting only new forestry plantings (afforestation and reforestation) on agricultural land since 1990 are counted. The impact of this difference is significant as it reduces the 1990 baseline under UNFCCC accounting when the growth in emissions is being calculated.

Factors influencing subsectoral emissions projections

Sequestration from commercial forestry, environmental planting and managed native forests is dependent on the area of the forestry estate, the contribution of forest growth in each year and the rate of harvesting. In all cases, projections rely on estimates of the amount of carbon sequestered in biomass, which differ by tree species and for different climatic and geographical conditions.

Emissions from land-use change are influenced by the area of forest cover removal and the method of forest conversion and land development, and rely on estimates of the amount of carbon sequestered in biomass and soils, which differ by vegetation type, geography and climate. Recent rates of forest cover removal have varied according to seasonal conditions (particularly rainfall), vegetation management regulation and commodity prices.

The trends in the LULUCF sector are also influenced by inter-annual climate variability and natural disturbances.

Analytical approach followed

Modelling has been updated in accordance with the IPCC accounting rules for LULUCF (IPCC 2003).

The projected areas of future forest plantation establishments have been provided on a regional basis by the Bureau of Rural Sciences. Remote sensing methods to identify areas of reforestation have also been further developed since the publication of the Fourth National Communication. These methods have been used to identify areas of new plantings since 1990.

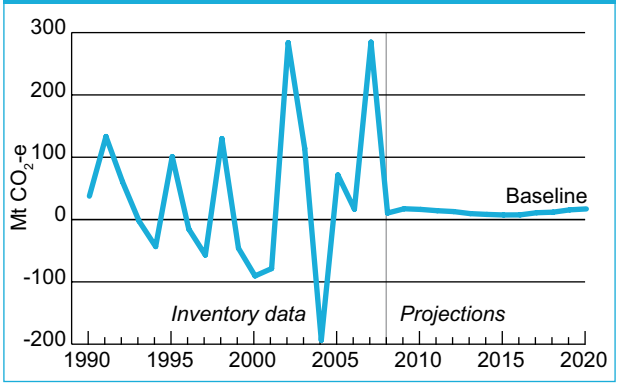
Baseline projections (under UNFCCC accounting rules)

From year to year, the LULUCF sector may change from a net source to a net sink. The trend in net emissions in the early 1990s was driven by the reduction in forest conversion emissions; the shift from a net sink to a net source in 1995, 1998 and 2002 and the large spike in 2007, however, were due to natural disturbances, such as fires and severe drought conditions which caused a loss of carbon from all pools.

It is difficult to project emissions and removals for some land use categories due to these large annual variations. Therefore, components of the LULUCF sector that are driven primarily by climate variability and natural disturbance have been projected to have zero net emissions.

Figure 5.9 shows historical and projected emissions from this sector.

***Figure 5.9** Net emissions from the land use, land-use change and forestry sector (Mt CO_2-e), 1990 to 2020 (UNFCCC accounting method)*



Baseline projections (under Kyoto accounting rules)

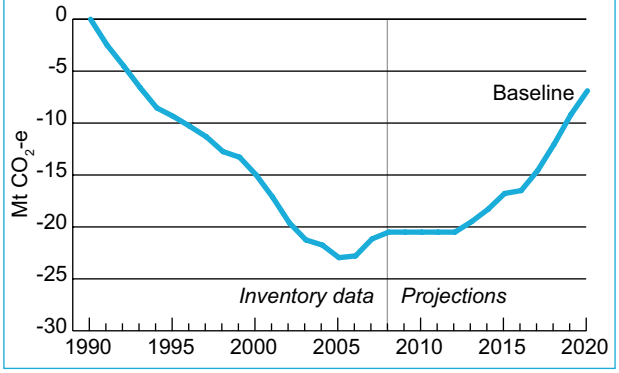
Forestry

The forestry subsector, under Kyoto accounting rules, covers new forests established by direct human action on land not forested in 1990. In line with the approach established in the second sentence of Article 3.7 forestry sinks are not included in the 1990 base, and only afforestation and reforestation occurring after 1 January 1990 is credited.

Current projections are for 20.5 Mt CO_2-e per year to be sequestered under the Kyoto rules for afforestation and reforestation for the period 2008 to 2012. The projection post-2012 assumes the harvest sub-rule does not continue after the end of the first commitment period. This is a conservative approach given that the LULUCF accounting rules are currently under negotiation.

Figure 5.10 shows historical and projected emissions from this sector.

***Figure 5.10** Emissions from the forestry sector (Mt CO_2-e), 1990 to 2020 (Kyoto accounting method)*



Land-use change

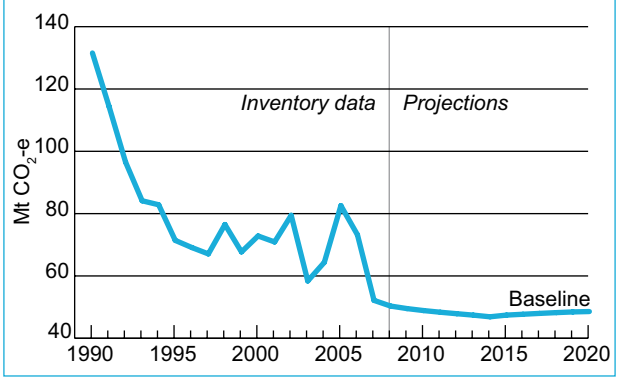
Deforestation is included in the emissions accounts for both 1990 and 2008–12 under the Kyoto Protocol rules applying to Australia.

The projection has been undertaken using a new National Carbon Accounting System tier 2 model that provides an approximation to the full model for projections purposes. The tier 2 model projects land-use change emissions on the basis of anticipated rates of initial forest conversion and regrowth clearing in each state, together with the historical relationships in the full model between these areas and emissions.

Emissions from land-use change are estimated at 132 Mt CO_2-e in 1990. These emissions are projected to be 49 Mt CO_2-e in 2010. This represents a 63% decrease on 1990 levels. The 2020 projection is also 49 Mt CO_2-e.

Figure 5.11 shows historical and projected emissions from this sector.

***Figure 5.11** Emissions from the land-use change sector (Mt CO_2-e), 1990 to 2020 (Kyoto accounting method)*

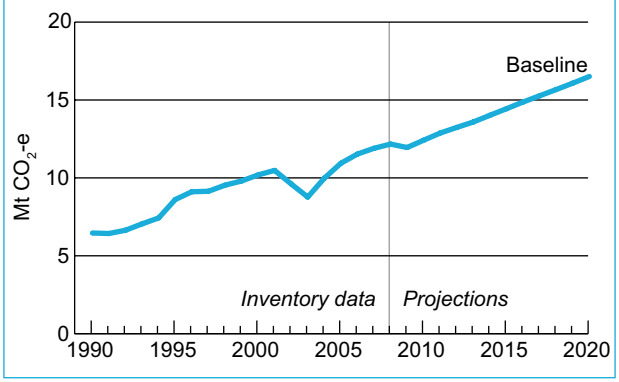


5.4.8 Projections of international bunker fuels emissions

International bunker fuels are fuels used for the purpose of international trade and travel between Australia and other nations, which is dominated by aviation fuel. Emissions from this sector almost doubled from 1990 to 2007, and are projected to continue to increase. The expected increase is a result of rapid projected growth in trade and international travel. In line with UNFCCC accounting rules, emissions from international bunker fuels are not counted in the total emissions for Australia.

Figure 5.12 shows historical and projected emissions from this sector.

***Figure 5.12** Emissions from international bunker fuels (Mt CO_2-e), 1990 to 2020*



5.4.9 Projections by gas

The sectoral projections provided in the sector-by-sector analysis are shown on a carbon dioxide equivalent (CO_2-e) basis. This is the aggregate of the individual greenhouse gas species multiplied by their global warming potential. Table 5.10 shows the breakdown of emissions in each sector by gas species.

***Table 5.10** Emissions estimates by sector by gas, baseline (Mt CO_2-e), 1990 to 2020 (UNFCCC accounting method)*

		Stationary energy	Transport	Fugitive	Agriculture	Waste	Industrial processes	Land use, land-use change and forestry
1990								
	CO_2	192.6	60.7	6.0	na	na	18.5	30.5
	CH_4	1.8	0.6	23.2	70.7	18.3	0.1	5.1
	N_2O	0.7	0.7	–	16.1	0.5	–	2.0
	PFCs	na	na	na	na	na	4.0	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	1.1	na
	Total	195.1	62.1	29.2	86.8	18.8	24.1	37.6
1995								
	CO_2	210.8	66.5	5.9	na	na	21.0	96.8
	CH_4	1.9	0.7	25.2	68.6	17.5	0.1	3.0
	N_2O	0.8	1.1	–	17.8	0.5	–	1.3
	PFCs	na	na	na	na	na	1.3	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	0.8	na
	Total	213.5	68.2	31.1	86.3	18.0	23.8	101.0
2000								
	CO_2	248.4	72.8	6.7	na	na	22.0	–94.7
	CH_4	1.6	0.7	26.1	72.7	15.3	0.1	2.9
	N_2O	0.9	1.5	–	22.0	0.5	–	1.3
	PFCs	na	na	na	na	na	1.1	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	2.0	na
	Total	250.9	74.9	32.8	94.7	15.8	25.7	–90.5

Table 5.10 ***(continued)***

		Stationary energy	Transport	Fugitive	Agriculture	Waste	Industrial processes	Land use, land-use change and forestry
2005								
	CO_2	278.9	75.2	5.6	na	na	21.6	66.5
	CH_4	1.2	0.6	27.1	69.0	13.9	0.1	3.7
	N_2O	1.0	1.8	–	20.5	0.6	–	1.4
	PFCs	na	na	na	na	na	1.5	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	4.6	na
	Total	281.1	79.0	32.7	89.6	14.4	28.4	71.6
2010								
	CO_2	290.3	78.8	7.2	na	na	25.0	15.1
	CH_4	1.3	0.6	31.9	67.6	14.2	0.1	0.8
	N_2O	1.0	1.7	–	20.7	0.6	–	0.3
	PFCs	na	na	na	na	na	0.4	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	6.6	na
	Total	292.5	81.3	39.1	88.2	14.8	32.6	16.3
2015								
	CO_2	303.6	86.4	10.3	na	na	26.7	6.8
	CH_4	1.3	0.7	36.1	72.1	14.4	0.1	0.4
	N_2O	1.0	1.9	–	22.1	0.6	–	0.1
	PFCs	na	na	na	na	na	0.5	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	7.6	na
	Total	305.9	88.9	46.4	94.2	15.0	35.4	7.4
2020								
	CO_2	319.2	92.6	16.4	na	na	28.3	15.8
	CH_4	1.4	0.7	44.1	74.3	14.8	0.1	0.9
	N_2O	1.1	2.0	–	22.8	0.6	–	0.3
	PFCs	na	na	na	na	na	0.5	na
	SF_6	na	na	na	na	na	0.5	na
	HFCs	na	na	na	na	na	8.0	na
	Total	321.6	95.3	60.6	97.0	15.4	37.5	17.1

na—not applicable

5.5 Projections methodology

Australia's broad approach to emissions projections was discussed earlier (see 5.1). Emissions are projected by aggregating the various sectoral projections, which were also described individually in earlier sections of this chapter. However, some methodological points are common to all projections and are briefly discussed here.

Baseline projections include an estimate of the impact of current greenhouse gas abatement measures. Greenhouse gas abatement measures are defined as measures that have been implemented or supported by regulation, fiscal incentive, or other policy initiatives at the Australian, state and territory or local government level.

Business-as-usual projections exclude all greenhouse gas abatement measures adopted or implemented since 1990.

The dominant approach used to project emissions for each sector is to project the relevant sectoral activity levels and to convert these into emissions using the National Greenhouse Gas Inventory methodology. Thus, the historical emissions factors—the quantity of greenhouse gases emitted per unit of a specific activity—are consistent with the National Greenhouse Gas Inventory and form the basis for projected emissions factors.

A number of key sectors incorporate multiple models:

- the stationary energy projections include projections from top–down computable general equilibrium models
- several sectors use bottom–up projections or econometric models
- projections from each model class are combined using a simple average approach and the final best estimate is a simple average of the combined result for each model class.

More detail on the projections for each sector will be presented in forthcoming Department of Climate Change publications. This will include information that reconciles new and earlier projections, and provide details of the relevant methodologies for each sectoral projection. Stakeholders are consulted for projections in each sector to provide their views and ensure quality.

5.5.1 Uncertainty and sensitivity analysis

Emissions projections are inherently uncertain, involving judgments about the future of the global and national economy, policy actions affecting emissions, technological innovation and other human behaviour.

High and low scenarios are published for the majority of sectors to provide a plausible range of emissions outcomes that reflect the impact of simultaneous deviations in key variables from the modellers' best outcomes. Sensitivity analysis of the impact on the projections of variations in individual key assumptions is also undertaken. Since the key assumptions vary from sector to sector, different assumptions and variables are adjusted in the sensitivity analysis across the sectors.

The aim is to provide greater understanding of the key risks related to the projections, to complement the emphasis placed within each sectoral projection on understanding the key drivers of the projection. Scenario analysis can aid policy makers by providing a tangible link from changes in key drivers to their potential impact on the projection. Given the complexity of the models used, and uncertainty about both the likely future distribution of the values of key drivers and the correlations between them, no attempt is made to quantify overall confidence intervals using the Monte Carlo analysis.

However, an indicative estimate of uncertainty can be obtained by combining the various sectoral high and low scenarios. These scenarios give a range of 549 to 581 Mt CO_2-e in 2010, or 121% to 128% of 1990 levels using UNFCCC accounting provisions. Under the Kyoto accounting framework, the scenarios give an uncertainty range of 103% to 109%, which is 3% around the central estimate of the Kyoto projection. These ranges are based on the following scenarios:

- the low scenario combines all of the sectoral low estimates, and the best estimate for forestry and land-use change
- the high scenario combines all of the sectoral high estimates, and the best estimate for forestry and land-use change.

These scenarios will likely understate total uncertainty as they do not include contributing uncertainty from the land use, land-use change and forestry estimates.

References

ABARE (Australian Bureau of Agricultural and Resource Economics), 2009a, *Australian Commodities September Quarter 09.3*, ABARE, Canberra.

—— 2009b, *Australian Commodities March Quarter 09.1*, ABARE, Canberra.

Australian Greenhouse Office 2005, *Australia's Fourth National Communication on Climate Change*, Australian Greenhouse Office, Canberra.

Australian Petroleum Production and Exploration Association 2009, APPEA Annual Production Statistics [Online], available at www.appea.com.au.

Australian Petroleum Production and Exploration Association annual survey.

Australian Petroleum Production and Exploration Association detailed industry emissions inventories.

CofA (Commonwealth of Australia) 2008a, *Australia's Low Pollution Future: The economics of climate change mitigation report*, Canberra.

—— 2008b, *Carbon Pollution Reduction Scheme: Australia's low pollution future*, 2 vols, Canberra.

—— 2009, *Mid-Year Economic and Fiscal Outlook*, Commonwealth of Australia, Canberra.

DCC (Department of Climate Change) 2009a, *Australian National Greenhouse Accounts: National Inventory Report 2007*, 2 vols, Canberra.

—— 2009b, *Tracking to Kyoto and 2020: Australia's greenhouse gas emissions trends 1990 to 2008–12 and 2020*, Canberra.

IPCC (Intergovernmental Panel on Climate Change), 2003, *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, Institute for Global Environmental Strategies, Hayama.

—— 2006, *IPCC Guidelines for National Greenhouse Gas Inventories*, Institute for Global Environmental Strategies, Hayama.

UNFCCC (United Nations Framework Convention on Climate Change), 2000, *Review of the Implementation of Commitments and of Other Provisions of the Convention: UNFCCC guidelines on reporting and review*, United Nations Office at Geneva.

—— 2006, *Updated UNFCCC Reporting Guidelines on Annual Inventories Following Incorporation of the Provisions of Decision 14/CP.11*, United Nations Office at Geneva.

—— 2008, *Kyoto Protocol Reference Manual on Accounting of Emissions and Assigned Amount*, UNFCCC, Bonn.

—— 2009, *Report of the Review of the Initial Report of Australia*, United Nations Office at Geneva.

US Energy Information Administration 2009a, *Annual Energy Outlook 2009 with Projections to 2030*, Energy Information Agency, Washington DC.

—— 2009b, *Short-term Energy Outlook: November 10, 2009 release*, available at www.eia.doe.gov.

Wood Mackenzie Ltd 2009, *Coal Supply Service™*, available at www.woodmacresearch.com.

CHAPTER 6

Climate change vulnerability and adaptation

KEY DEVELOPMENTS

Adaptation is one of the three pillars of the Australian Government's climate change policy. The Australian Government's efforts on adaptation over the reporting period have been focused on building the information needed to underpin sound decision making at the national level and coordinating the economic and regulatory reforms needed to better address climate change risks at the national level. State, territory and local governments have focused their initiatives at the regional level and have had the lead on direct adaptation action.

In 2007 the Council of Australian Governments endorsed the National Climate Change Adaptation Framework to guide practical activities over the next five to seven years. Adaptation actions by governments have been guided by priorities identified in the framework.

During the reporting period, Australia has made significant investments in developing the knowledge and tools needed to deliver adaptation responses. Australian governments have funded research to increase understanding of the impacts of climate change, undertaken vulnerability assessments and implemented adaptation measures in key vulnerable sectors and regions in order to build adaptive capacity and increase efficient risk management.

Adapting to the impacts of unavoidable climate change is critical to any effective climate change response. Along with efforts to reduce domestic emissions and helping to shape a global solution, adaptation is one of the three pillars on which Australia's comprehensive climate change strategy is built (see also Chapter 4).

Adapting to the impacts of climate change will be a substantial ongoing challenge for all Australians well into the future. An effective response to climate change will require contributions from and engagement by all levels of government, as well as business and the community. Governments, businesses and the community have important, complementary and differentiated roles in preparing Australia to deal with the impacts of unavoidable climate change that threaten assets, investments, environments, communities and regional economies around the country.

Given their greater role in service delivery, land use and planning, and management of assets, state, territory and local governments have a major role in and responsibility for direct adaptation action. The Australian Government's actions focus on building the tools and information needed to underpin sound decision making at a national level and coordinating the economic or regulatory reforms needed to better address climate change risks where they may affect more than one jurisdiction.

The Australian Government has been working with state, territory and local governments, through the Council of Australian Governments, to develop a national adaptation response to position Australia to manage efficiently the risks arising from climate change.

During the reporting period, all levels of government have initiated programs and initiatives that aim to build Australia's capacity to adapt to the impacts of climate change. These programs include those that deliver key information to help decision makers understand and manage risks arising from the impacts of climate change, and that support partnerships to facilitate adaptation responses in highly vulnerable sectors and regions.

6.1 Expected impacts of climate change on Australia

Adaptation responses need to be underpinned by sound climate science. The Australian Climate Change Science Program (see 8.2.2), which is a collaboration between the Australian Government, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Bureau of Meteorology and leading universities, has provided the foundation for understanding the expected impacts of climate change on Australia. Through a focus on observing key climate processes in the oceans, cryosphere, atmosphere and land, the program is able to monitor changes in climate and inform the development of Australia's global climate model (the Australian Community Climate and Earth System Simulator), which enables the projection of how climate change will affect factors such as temperature, rainfall, drought, heatwaves, fire weather, storm intensity and sea level.

Developing a comprehensive understanding of the impacts of climate change on Australia is essential to assessing exposure, risks and opportunities arising from climate change, thus allowing the development of robust and evidence-based policy responses.

While Australia needs to continue to build its understanding of climate change, some indications of the potential impacts and costs to the nation's industries, environment, people and infrastructure are already emerging. The following subsections provide examples of some of these impacts in key vulnerable sectors.

6.1.1 Water resources and supply

Australia is the world's driest inhabited continent, and the effect of climate change on its hydrological cycle is critical. Potential changes to water availability have significant implications for Australia's economic, social and environmental wellbeing. Climate change will impact on water availability across Australia as a result of shifts in rainfall patterns and increased evaporation.

Climate change is already having a significant impact on water availability and security across Australia. Some observed changes in rainfall trends are now, in part, being attributed to climate change (CSIRO & BoM 2007; Cai & Cowan 2007). Modelled rainfall projections (largely consistent with observations) indicate that Australia will face increasing threats to its water security (CSIRO & BoM 2007). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change found that Australia's water security would exceed its adaptive capacity and become vulnerable with a 2°C increase in global temperature (IPCC 2007b, pp. 515, 517, 520, 524, 528–9).

Reduced stream flows, likely due to increased temperatures and reduced rainfall, will have significant implications for urban and agricultural water supply and the environmental health of rivers. Australia will need to address a decline in water quality, associated with declining stream flows as a result of impacts of climate change. Eutrophication and toxic algal blooms are likely to become more frequent and last for longer, threatening human and livestock health and the ecological functioning of river systems (IPCC 2007b, p. 517). Likely changes to the frequency and intensity of fires may also have an impact on the quality of urban water supply through increased catchment erosion and contamination (eWater CRC n.d.).

In the Murray–Darling Basin, with no mitigation and continued irrigation, water availability is projected to diminish, leading to a 92% decline in the value of irrigated agriculture by 2100 (Garnaut Climate Change Review 2008a). CSIRO's Sustainable Yields Project, which examined the impact of climate change on Murray–Darling Basin rivers, forecasted significant reductions in surface water availability by 2030 (CSIRO 2008).

The projected increase in the intensity of extreme rainfall events in some areas poses increased pressure on water storage infrastructure, increased risk of flood damage and possible changes to ecosystems (Garnaut Climate Change Review 2008b; Steffen et al. 2009). Increases in extreme daily rainfall are likely where average rainfall either increases or decreases slightly, for example, the intensity of the 1-in-20-year daily rainfall event is likely to increase by up to 30% in south-east Queensland by 2040 (IPCC 2007b, p. 515).

6.1.2 Coasts

Around 85% of the Australian population lives in the coastal zone. Sea levels increased by approximately 17 cm over the 20th century, largely due to thermal expansion. The rate of sea-level rise is accelerating and impacts are already being observed (IPCC 2007a, p. 7). Long-running tide-gauge records from Fremantle in Western Australia and Fort Denison in Sydney show that extreme sea-level events were three times more common during the second half of the 20th century than during the first half (Antarctic Climate & Ecosystems Cooperative Research Centre 2008, p. 7).

Sea-level rise is almost certain to cause greater coastal inundation, erosion, loss of wetlands and saltwater intrusion into freshwater sources, with impacts on infrastructure, coastal resources and existing coastal management programs.

The frequency of extreme sea-level events may increase many times with even modest sea-level rise. With a mid-range increase of 0.5m, extreme sea-level events that now happen every few years are likely to occur every few days by 2100 (Antarctic Climate & Ecosystems Cooperative Research Centre 2008, pp. 12–13). This will have serious implications for coastal zone management, including for communities, infrastructure, planning regulation, aquaculture and coastal ecosystems.

Along with sea-level rise, the coastal zone faces potential impacts from changes to weather patterns, ocean currents, ocean temperature and storm surges. Ocean acidification is also likely to impact on coastal natural systems, particularly coral reefs.

6.1.3 Infrastructure

Substantial infrastructure in Australia is at risk from climate change. About US$1125 billion of Australia's wealth is invested in homes, commercial buildings, ports and physical assets, many of which are exposed to some extent to extreme weather events, drought and sea-level rise as a result of climate change (Coleman et al. cited in IPCC 2007b, p. 521). Modelling by the Garnaut Climate Change Review (2008c) suggests that climate change impacts on infrastructure could reduce Australia's gross national product by 1.23% by 2050 and 2.42% by 2100, compared to a reference case without climate change.

Infrastructure in Australia is projected to suffer negative impacts from increased temperature, reduced water availability, sea-level rise, and increased frequency and intensity of extreme events. Key areas of vulnerability include infrastructure located in the coastal zone, such as ports, roads and bridges and infrastructure for water, electricity and telecommunication services.

While individual events cannot yet be attributed to climate change, recent extreme weather events demonstrate the vulnerability of infrastructure to the likely impacts of climate change. During the February 2009 heatwave in south-eastern Australia, the Basslink interconnector, a submarine power cable that connects Tasmania to the mainland, shut down when its design limits for temperature extremes were exceeded at both ends of the cable. In Melbourne, train lines buckled under the intense heat, leaving commuters stranded;

a million homes were affected by blackouts and rolling power cuts. The catastrophic 2009 Victorian bushfires destroyed extensive infrastructure, including telecommunications, which is vital to emergency responses.

Modelling for the Garnaut Climate Change Review (2008b) revealed that impacts of climate change on infrastructure would be moderate to extreme by 2100 in the absence of mitigation. In some regions of Australia, water infrastructure would face extreme impacts as early as 2030 (Garnaut Climate Change Review 2008b).

6.1.4 Agriculture

Farmers manage 54% of the Australian landmass (ABS 2009), and agriculture directly contributes around 2% of gross domestic product in Australia (Gunasekera et al. 2008). The gross value of agricultural commodities produced in 2005–06 was $37.3 billion (ABS 2008).

Modelling by the Australian Bureau of Agricultural and Resource Economics suggests that, while total agricultural output will continue to increase relative to today, over the next four decades climate change will result in a slower rate of growth, assuming no adaptation or mitigation (Gunasekera et al. 2008).

Projections indicate that there will be up to 20% more drought months over most of Australia by 2030 relative to 1990 levels under a high emissions (A1FI) scenario. By 2070, up to 40% more drought months are projected in eastern Australia and up to 80% more in south-western Australia (CSIRO & BoM 2007, p. 83). Drought has immediate and far-reaching consequences for all agricultural sectors and the economy in general.

Agricultural production will be vulnerable to declining rainfall, increased evaporation and reduced streamflow. While increasing atmospheric carbon dioxide may have a fertilisation effect for plants there is likely to be a net benefit to agriculture only if declines in rainfall are less than 10%.

Long-term temperature increases may impact on grain quality, disrupt fruiting of horticultural crops and expand the range of the Queensland fruit fly which damages crops (Garnaut Climate Change Review 2008d).

6.1.5 Iconic and productive natural systems

Australia's iconic and productive natural systems are highly vulnerable to climate change, given the low adaptive capacity of natural ecosystems compared to other sectors (IPCC 2007b, pp. 528–9). Particularly vulnerable areas include Kakadu National Park, the Wet Tropics, the Great Barrier Reef, alpine areas, the south-east Tasman Sea, and the south-west Australian heathlands (IPCC 2007b, p. 517). Natural systems are directly threatened by higher concentrations of carbon dioxide, increased temperatures, sea-level rise, changes in precipitation, and increases in extreme weather events and ocean acidification. Climate change will also exacerbate the many existing threats to Australia's biodiversity such as loss of habitat and introduced species.

The Great Barrier Reef is already experiencing the impacts of climate change through episodes of mass coral bleaching (Garnaut Climate Change Review 2008e, p. 7). In Australia's alpine regions, increased temperatures and a decline in natural snow conditions have been observed over the past 35 years (Hennessy et al. 2003). It is predicted that a continued decline in snow cover will lead to potential extinction of summit species (Steffen et al. 2009, pp. 121–3). The lowland parts of Kakadu National Park are vulnerable to changed salinity from sea-level rise and saline intrusion into groundwater (Australian National University 2009, p. 46).

6.1.6 Health

The impacts of climate change on the health of Australians will occur in several ways: through direct pathways (e.g. heatwaves and death), indirect pathways entailing disturbances of natural ecological systems (e.g. mosquito population range and activity) or disruption to livelihoods and communities (e.g. mental health consequences of prolonged droughts and regional drying trends) (Garnaut Climate Change Review 2008f).

An increase in extreme weather events, including heatwaves, floods, storms, cyclones and bushfires, will pose health risks for Australians (Garnaut 2008, p. 139). Extreme events can have direct health impacts through injury or death suffered during the event, and may also have indirect impacts through contamination of water supplies and the loss of property and livelihoods.

Modelling carried out for the Garnaut Climate Change Review indicates that climate change impacts on human health could reduce Australia's gross national product by 0.02% by 2050 and by 0.08% by 2100 compared to a reference case without climate change (Garnaut Climate Change Review 2008c).

While individual events cannot yet be attributed to climate change, recent events have demonstrated the likely health impacts associated with more extreme climate events. The February 2009 heatwave across south-east Australia had significant health impacts. There were 374 heat stress deaths reported in Victoria in excess of what would have been expected, with the greatest number of deaths occurring among those 75 years and older (representing a 64% increase on the expected figure) (Victorian Government Department of Human Services 2009).

An increase in heat-related deaths will be one of the most significant health impacts of climate change in Australia: the number of heat-related deaths is expected to overtake cold-related deaths in nearly all cities by 2050 (IPCC 2007b, p. 524).

Climate change will likely result in an increase in the incidence of dengue fever (with up to an extra 5.52 million people being exposed to dengue by 2100) (Garnaut Climate Change Review 2008f, p. 38), Ross River virus and food- and water-borne diseases (Garnaut 2008, p. 139). This increase will result in higher prevention and treatment costs and lost economic productivity through lost work days (Garnaut Climate Change Review 2008f, p. 38).

Climate change may have mental health impacts, with particular effects on rural (Garnaut Climate Change Review 2008g) and Indigenous Australians. Indigenous Australians have a holistic concept of health, with wellbeing of the body, mind and spirit grounded in connectedness to land. Negative climate change impacts on the land may become manifest in mental distress for Indigenous Australians (Garnaut Climate Change Review 2008h).

6.2 Vulnerability assessment

Climate change vulnerability assessments are an important element of Australia's systematic approach to responding to climate change. They increase our scientific understanding of climate-sensitive systems and help prioritise research on and response actions for the most vulnerable regions and sectors. This, in turn, informs the development of adaptation strategies to reduce vulnerability.

6.2.1 National-level vulnerability assessments

During the reporting period, the Australian Government has undertaken a number of strategic national vulnerability assessments in key vulnerable sectors identified in the National Climate Change Adaptation Framework. Key among these are the climate change risks to Australia's coastal areas, biodiversity, national infrastructure and Indigenous communities.

Australia's coastal areas

To better understand the risks of rising sea levels and other climate change impacts, the Australian Government has undertaken a first-pass national assessment of climate change risks to Australia's coastal areas. The assessment report, *Climate Change Risks to Australia's Coasts*, was released in November 2009. The assessment uses a sea-level rise scenario of 1.1 metres by 2100 based on the plausible range of sea-level rise values from recent research (conducted after the IPCC's Fourth Assessment Report). The study assesses the risks from climate change to natural and built assets in Australia's coastal zone, with a particular focus on the inundation and erosion risks associated with rising sea levels. The principal findings of the report are:

- Up to 247 600 existing residential buildings will be at risk of inundation under a sea-level rise scenario of 1.1 metres.
- Major coastal infrastructure such as airports and ports will be at risk from sea-level rise: 120 ports, 11 power stations, 199 hospitals and nearly 1000 universities, colleges and schools are located within 500 metres of the Australian coastline. Sydney Airport is almost entirely surrounded by waterways, and a sea-level rise of 1.1 metres combined with a storm surge would inundate parts of the airport.
- Climate change will increase a number of risks faced by industry, and bring new risks to some industries not previously exposed. For example, a number of Australia's key tourism regions are at high risk to climate change impacts, notably the Great Barrier Reef and Ningaloo Reef, Kakadu and the Top End coastal wetlands.
- The responses of Australian coastal ecosystems and landforms to climate change will vary but are expected to involve shoreline recession, vertical accretion, increased saline inundation of wetlands, and the modification and southward shift of habitat.

CLIMATE CHANGE RISKS TO AUSTRALIA'S COAST: A FIRST PASS NATIONAL ASSESSMENT

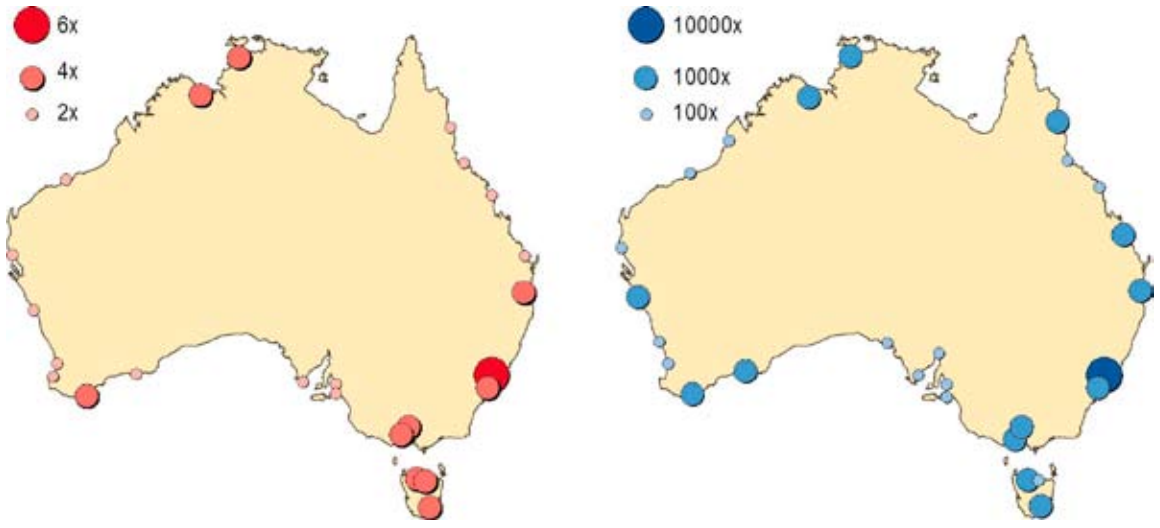
Erosion along the Queensland coast in 1967.

Australia has become a coastal society. Around 85% of the population now live in the coastal region and it is of immense economic, social and environmental importance to the nation. All Australian state capitals are located within the coastal zone, it is the conduit for our exports and imports, and much of the nation's commercial activities occur in coastal areas.

The Australian Government has undertaken a first-pass national assessment of the climate change risks to Australia's coasts to better understand the extent and magnitude of risk (report available at www.climatechange.gov.au). The report represents an important milestone in the assessment on a national scale of risks to the Australian coastline, identifying issues that will need further consideration and providing a solid basis for the development of resilient, robust and sustainable responses.

Over the geological past, the Australian continent has experienced sea levels up to four to six metres higher than today and the shoreline in some places was more than 500 km inland. Over the last 6000 to 7000 years, sea level around Australia has been relatively stable, which has generally allowed current landforms and ecosystems to persist without large-scale modifications. Settlements have been built along the Australian coast in expectation that sea level would remain broadly constant. However, those conditions are now changing. Changes driven by climate change will increase risks to settlements, industries, the delivery of services and natural ecosystems in Australia's coastal zone.

***Figure 6.1** Estimated increases in the frequency of high sea-level events*



Note: Estimates are for increases in the frequency of high sea-level events (indicated by the diameters of the circles) caused by sea-level rises of 0.1 metres (left) and 0.5 metres (right), showing that the increasing frequency of events for rising sea levels is not linear.

Source: Antarctic Climate & Ecosystems Cooperative Research Centre 2008.

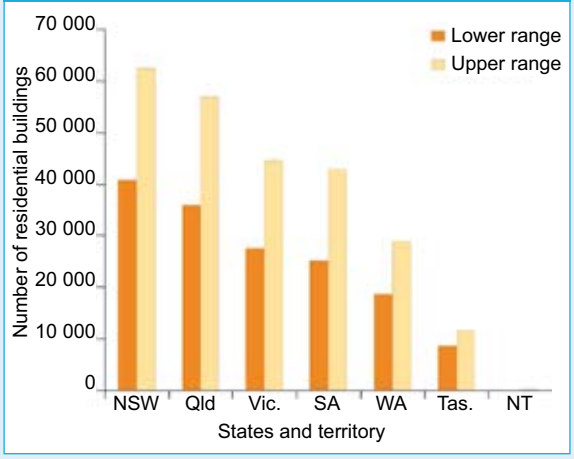
For Australia, analysis shows that with a mid-range sea-level rise of 0.5 metres in the 21st century, high sea-level events that now happen every 10 years would happen about every 10 days in 2100. The current 1-in-100-year event could occur several times a year (see Figure 6.1). This has wide implications because the 1-in-100-year event is generally used in current planning guidelines across Australia as a benchmark for assessing risk.

Over recent decades many Australian beaches have been stable or even accreting because the sediment supply has been sufficient. It is expected that climate change will alter this dynamic, and an important question is when stable or accreting beaches will flip to receding beaches in the face of rising sea levels. This is a key threshold for coastal management. It is possible that some beaches could recede hundreds of metres over the course of this century.

The first-pass national coastal assessment brings together existing and new information to highlight the scale of problem Australia faces as a vulnerable coastal nation. The assessment analysed the risks to residential property from erosion and inundation using a sea-level rise value of 1.1 metres. It identified up to 247 600 existing residential buildings at risk of inundation from sea-level rise combined with high tide or storm tide (see Figure 6.2).

It has also assessed risks of climate change to coastal ecosystems, industries and infrastructure such as ports and airports. Sea-level rise, more intense cyclones and ocean acidification will potentially increase the capital and operating costs of ports significantly by mid-century. A number of airports are located in low-lying areas in the coastal zone, and are at risk of inundation from sea-level rise and storm surges. Sydney Airport is almost entirely surrounded by waterways, and a sea-level rise of 1.1 metres combined with a storm surge would inundate parts of the airport in the absence of adaptation. At risk also will be coastal industries, such as tourism, that depend on natural assets likely to be impacted by climate change (such as the Great Barrier Reef and Kakadu National Park).

***Figure 6.2** Estimated number of residential buildings at risk of inundation from sea-level rise of 1.1 metres*



Note: Estimate is of the number of residential buildings at risk of inundation from sea-level rise of 1.1 metres (including 1-in-100-year storm tide for New South Wales, Victoria and Tasmania, and high tide event for other states and the Northern Territory).

Terrestrial and aquatic plants and animals that rely on coastal habitat are likely to be adversely affected by sea-level rise, increases in sea surface temperature and ocean acidification. Change in coastal ecosystems is already occurring—for example, southward migration of some species has been observed, particularly along the south-east coast of Australia.

A major question for several coastal ecosystems is whether they are likely to face a threshold with modest climate change beyond which they will move into a less desirable state. Ecosystem responses to climate change are expected to include inland or poleward migration. In southern Australia the effect of 'coastal squeeze', where built infrastructure such as housing development prevents such movement, could constrain this natural adaptation response. The coastal systems most at risk are estuaries and associated wetlands, coral reefs, constrained tidal flat communities and saltmarshes, and beaches where there is a lack of sediment for replenishment.

The report acknowledges the limitations to the modelling used in the assessment—local hydrological processes were not modelled, and storm tide data were not available for all states.

Biodiversity

The Australian Government commissioned a strategic national assessment of the vulnerability of Australia's biodiversity to climate change in order to better understand the impacts of climate change on Australia's biodiversity and to support effective policy and management responses to the threat to biodiversity from climate change. The report of the assessment, *Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change*, was released in August 2009.

The report concludes that Australia's biodiversity is particularly susceptible to the rate and magnitude of climate change under way; that major changes are likely in ecosystem processes and in the distribution and abundance of species; that species extinctions are likely to result from temperature increases of greater than 1.5° to 2°C; and that a business-as-usual approach to planning and management for biodiversity conservation is likely to be inadequate.

The assessment provides a foundation for future adaptation activities for Australia's unique biodiversity, including the current review of the *Environment Protection and Biodiversity Conservation Act 1999* and the Australian Government–led development of Australia's Biodiversity Conservation Strategy 2010–2020.

National infrastructure

The Australian Government is currently assessing the risks from climate change to major national infrastructure, covering water, energy, transport, communications and buildings. Through this assessment, priority areas for further research will be identified.

An economic analysis of climate change impacts on infrastructure is also under way. This study will be carried out through a series of case studies including the impacts of sea-level rise on a coastal community and of drought on a regional water supply system. Both studies will assist the Australian Government to develop and deliver appropriate adaptation policy responses that build resilience to climate change impacts.

Indigenous communities in the tropical north

The *Scoping Study on the Risks from Climate Change to Indigenous Communities in the Tropical North of Australia* was commissioned by the Australian Government to identify the impacts of climate change on Indigenous communities in the tropical north and assess their vulnerability and adaptive capacity. This pilot study, the first of its kind in Australia, included an evaluation of the current literature, spatial analysis, interviews with key stakeholders and eight case studies of Indigenous communities.

The main areas being investigated are the impacts of climate change on Indigenous health, education and livelihoods; impacts on infrastructure and services; impacts on biodiversity; and opportunities from climate change for Indigenous communities. The findings of the study will inform future policy options to improve the resilience of Indigenous communities and assist them in adapting to meet the threat of climate change.

Vulnerability assessment reports

In addition to the reports discussed above, since Australia's Fourth National Communication on Climate Change the Australian Government has released a number of commissioned national-level vulnerability assessment reports, including:

- *Impacts of Climate Change on Australian Marine Life* (2006)
- *Climate Change and the Great Barrier Reef: A vulnerability assessment* (2007)
- *Implications of Climate Change for Australia's National Reserve System: A preliminary assessment* (2008)
- *The Impacts and Management Implications of Climate Change for the Australian Government's Protected Areas* (2008)
- *Managing Australian Landscapes in a Changing Climate: A climate change primer for regional natural resource management bodies* (2008)
- *Implications of Climate Change for Australia's Fisheries and Aquaculture: A preliminary assessment* (2008)
- *Implications of Climate Change for Australia's World Heritage Properties: A preliminary assessment* (2009)

All are available at www.climatechange.gov.au/publications/index.html.

These reports have provided valuable direction and information for decision makers in these vulnerable sectors to better enable the development of climate change adaptation strategies.

6.2.2 Regional vulnerability assessments

The Australian Government's national-level vulnerability assessments are complemented by a range of assessments commissioned to evaluate vulnerability to climate change impacts at the regional level. These will assist decision makers to frame adaptation responses to the likely impacts of climate change on regional and local issues.

The South East Queensland Initiative is a collaborative project by the Australian and Queensland governments, CSIRO and three Queensland-based universities. The initiative is the first comprehensive and large-scale integrated regional vulnerability assessment ever undertaken in Australia. The assessment, along with the new work on climate science and climate projections (see Chapter 8), will also provide the basis for the development of adaptation strategies for a range of important sectors, including energy, insurance, emergency services, health, primary industries and key ecosystems in this diverse region. Other main elements of the research include an exploration of the financial, environmental and social costs of different adaptation options leading to the development of adaptation strategies.

The Great Barrier Reef Marine Park Authority coordinated a major assessment of the vulnerability of the Great Barrier Reef and its stakeholders to climate change, *Climate Change and the Great Barrier Reef: A vulnerability assessment* (2007). This assessment focused on the vulnerability of species and habitats, considered stakeholders' roles in the management of the Great Barrier Reef and identified strategies for building resistance to the effects of climate change. Its findings informed the development of the Great Barrier Reef Climate Change Action Plan 2007–2012.

The authority also released the first *Great Barrier Reef Outlook Report 2009*, which recognises the Great Barrier Reef as one of the most diverse ecosystems in the world, with one of the healthiest coral reef ecosystems. Climate change, along with water quality decline and loss of coastal habitats, is, however, identified as a priority issue that is reducing the resilience of the Reef.

CSIRO's Water for a Healthy Country National Research Flagship has completed the Murray–Darling Basin Sustainable Yields Project, which involved assessments of current and future water availability in the Murray–Darling Basin. The major investigation included a determination of the impacts upon water resources of climate change and variability. This project has been followed by similar studies focused on northern Australia, Tasmania and south-west Western Australia.

The National Wind Risk Assessment, a nationally consistent assessment of wind risk under current climate conditions and for a range of climate change scenarios, is under way. The assessment will produce an updated understanding of severe wind hazard associated with cyclonic, thunderstorm and weather fronts. Assessments of wind risk (including estimates of damage and losses) will focus on residential and commercial structures in communities with populations of 20 000 or more, and four regions will be the subjects of detailed case studies.

The Climate Adaptation Flagship – Tropical Cyclone project is a collaboration between CSIRO, the University of Melbourne and Geoscience Australia. It began in 2008 and is due for completion in 2011. The project aims to provide better estimates of tropical cyclone wind hazard and risk in current and future climates across Australia. It is evaluating climate models that best simulate tropical cyclones, and then downscaling the results from these models to derive projections of tropical cyclone characteristics.

The Tropical Cyclone Risk Model, developed by Geoscience Australia, will assess the impacts of tropical cyclone winds in the current and future climate regimes. The model generates synthetic records of potential tropical cyclone wind fields and tracks, based on a representative sample of historical tropical cyclone tracks. Using information from downscaled general circulation models, the model can be used to evaluate cyclone hazard and risk under future climate conditions.

The Climate Futures for Tasmania project is a partnership between Geoscience Australia, the University of Tasmania, the Tasmanian Government and CSIRO. Due for completion in 2010, the project is investigating projected changes in severe wind hazard and risk for the Tasmanian region; it is downscaling several global climate models over Tasmania to simulate current local weather patterns and generate climate projections to 2100.

An investigation of the impacts of climate change on maritime boundaries is under way. This investigation is a partnership between Geoscience Australia, the Attorney-General's Department, the Department of Foreign Affairs and Trade and the Australian Hydrographic Service.

The definition of many of Australia's maritime boundaries is dependent on the location of the coastline. Sea-level change, changes in prevailing weather patterns, extreme weather events and acidification of the world's oceans have the potential to have an impact on the location of the coastline at a scale that will affect a number of maritime boundaries. This investigation, undertaken under the existing boundaries management framework, will identify the extent of this vulnerability and explore options that can mitigate the disruption caused by these changes.

The Australian Government supported the development of shallow water bathymetry models for priority areas of the Cocos Islands, Tonga and Solomon Islands in 2008 and 2009. Geoscience Australia and the Pacific Islands Applied Geoscience Commission used data from a variety of satellites to develop the models, which are being used by a range of stakeholders to underpin vulnerability assessments and the development of emergency management plans and adaptation strategies.

The newly established Water Information Research and Development Alliance brings together CSIRO's research and development expertise in water and information sciences and the Bureau of Meteorology's operational role in hydrological data, monitoring, assessment and prediction to transform the way Australia manages its water resources. The centrepiece of this alliance will be the Australian Water Resources Information System, which will provide researchers with access to regional and national data and information. This collaborative alliance will also provide research and development for improved hydrological datasets and models, water resource assessments, water accounts and predictions. New seasonal and long-term water forecasting methods will assist in understanding the impacts of climate variability and climate change on water availability for improved decision making and the development of future policy on water supply and use.

In 2006 the Council of Australian Governments identified as a priority the development of a national digital elevation model for the whole of Australia as a priority to assess climate change impacts for Australia's coasts, with vulnerable regions being mapped using very high-resolution images. The Australian Government has since invested in a mid-resolution digital elevation model for the entire Australian coastline, which was used in the first-pass national coastal risk assessment (see 6.2.1).

A number of jurisdictions are also investing in high-resolution digital elevation modelling. The New South Wales Government is undertaking a major project to significantly improve the NSW surface model—a digital elevation model for use in planning and decision making. The project will initially focus on coastal areas of New South Wales. The Victorian Government's Future Coasts Program has invested in a topographic digital elevation model for the entire Victorian coastline, which is currently being used by local governments and coastal agencies to undertake local risk assessments. More recently the Queensland Government announced additional investment in elevation data to better understand the impacts of sea-level rise, storm surge and coastal erosion along Queensland's coastline in a changing climate.

The Spatial Information Council is currently coordinating a National Elevation Data Framework to improve the quality of elevation data and derived products, optimise investment in data collections and provide wide access to users. The Australian Government is acquiring high-resolution elevation data for key urban centres, which is being used to pilot the National Elevation Data Framework. The elevation data derived from this project will be available for public use through an online portal.

6.3 Adaptation measures

Australian governments at the national, regional and local levels are carrying out a range of adaptation actions in vulnerable sectors and regions to prepare Australia to manage the risks arising from the impacts of climate change. In developing these actions, governments have drawn on the lessons and insights learned from the vulnerability assessments described in this chapter (6.2), from research and from adaptation policies and measures.

Building on preliminary work on adaptation conducted by a number of intergovernmental ministerial councils and by various jurisdictions, the Council of Australian Governments in April 2007 endorsed the National Climate Change Adaptation Framework as the basis for action by Australian governments over the subsequent five to seven years. The framework identified the most vulnerable sectors and regions, and included possible actions to assist these sectors and regions in adapting to the impacts of climate change. The National Climate Change Adaptation Framework has informed many of the actions outlined in this section.

6.3.1 Australian Government measures

The Australian Government's role in adaptation over the reporting period has been focused on building tools and information needed to underpin sound decision making; undertaking assessments and research to identify significant vulnerabilities to climate impacts; and coordinating economic or regulatory reforms needed to better address climate change risks where they may affect more than one jurisdiction.

The Australian Government is investing $170 million over five years (from 2007) to fund national adaptation actions. This investment includes establishment of the $44 million CSIRO Climate Adaptation National Research Flagship and the $126 million Climate Change Adaptation Program to lead Australian Government efforts to position Australia to manage the risks of climate change impacts. Actions under the program, administered by the Department of Climate Change, include key vulnerability assessments (see 6.2), funding of adaptation research, and generation of information and tools for decision makers.

In December 2007, the Australian Government established the Department of Climate Change, within the portfolio of the Prime Minister and Cabinet, with responsibility to lead the development and coordination of Australia's climate change policies. These responsibilities include developing policies and measures to support adaptation to the unavoidable impacts of climate change, the second pillar of the Australian Government's climate change policy; these include programs to improve knowledge of climate change impacts, to strengthen the capability of decision makers to respond, and to address major areas of vulnerability in Australia.

In 2008, the Australian Government, through the Department of Climate Change, provided up to $20 million to establish the National Climate Change Adaptation Research Facility (NCCARF) as part of the Climate Change Adaptation Program. This initiative will provide scientific leadership to the Australian research community in a national interdisciplinary effort to address problems relating to adaptation and to bridge the gap between science and policy.

The NCCARF will synthesise knowledge, coordinate research activities, broker research partnerships and generate information required by decision makers. It is supported by eight sectoral Adaptation Research Networks, which will harness research expertise to help build a collaborative environment that supports creative, interdisciplinary research, and advance priority sectoral research. The Australian Government is investing up to $30 million in these priority research areas.

6.3.2 State and territory government measures

In 2005, the New South Wales Government established the $2.2 million Climate Change Impacts and Adaptation Research Program to investigate key climate change impacts and vulnerabilities in areas including health, bushfire risk, invasive species and biodiversity, coastal impacts, and water supply and demand. The NSW Government has also established a Climate Change Science Research Network made up of leading academic researchers from a range of disciplines to provide technical advice on climate change policy and scientific advice.

The Victorian Government established the Climate Change Adaptation Research Centre as a central component of its Adaptation Program in 2009. The centre will be coordinated by the University of Melbourne with initial members including Monash University, La Trobe University and the Royal Melbourne Institute of Technology University. The research program for the centre will include annual forums to showcase research, a research grants program to complement the national adaptation effort, regional think tanks and a visiting fellowship program to draw on international expertise.

The Queensland Government has commenced a project with the Local Government Association of Queensland to review relevant science and flooding models to develop an improved methodology for assessing the risk of inland flooding in a changing climate and recommend policy options for flood risk management.

The Queensland Government's Growing the Smart State – PhD Funding Program supports research into climate change impacts on Queensland. Projects funded so far relate to impacts of climate change on rainforests; rare corals in North Queensland and other marine ecosystems; floodplain management; communities adapting to climate change; industry identifying and managing impacts; biodiversity; waste management; increasing frequency of heatwaves; and consumer behaviour impacts.

The South Australian Premier's Science and Research Council has been established to undertake collaborative research to develop new modelling and mapping (including decision mapping) to identify combinations of environment, land use, social and economic factors for regions to adapt to the impacts of climate change.

The Tasmanian Government has invested $900 000 in the Climate Futures for Tasmania project, being undertaken by the Antarctic Climate and Ecosystems Cooperative Research Centre. The project, co-funded by the Commonwealth Environment Research Facilities initiative and Hydro Tasmania, will model climate projections at a local scale and assess potential impacts on agriculture, water catchments, extreme events and infrastructure assets.

In 2008, the Australian Capital Territory Government provided a grant of $2.5 million towards the establishment of a Climate Change Adaptation Research Centre at the Australian National University.

6.3.3 Sectoral measures

Australian governments at the national, regional and local levels have carried out a range of adaptation actions in the key sectors identified in the National Climate Change Adaptation Framework as most vulnerable to the impacts of climate change. This section briefly outlines the adaptation measures implemented in these sectors since the Fourth National Communication.

Biodiversity and natural ecosystems

The Australian Government's Caring for our Country initiative is jointly administered by two Australian Government departments: Agriculture, Fisheries and Forestry, and Environment, Water, Heritage and the Arts. This initiative, which began in July 2008, is aimed at achieving an environment that is healthier, better protected, well managed, resilient, and provides essential ecosystem services in a changing climate. Caring for our Country encourages the adoption of sustainable land management practices that slow land degradation processes and increase the resilience of farms and agricultural landscapes to the effects of climate change.

The Caring for our Country initiative has integrated many of the Australian Government's previous natural resource management programs including the National Heritage Trust, the National Action Plan for Salinity and Water Quality, and the National Landcare, Environmental Stewardship, and Working on Country Indigenous Land and Sea Ranger programs.

While many of the funded activities under Caring for our Country support adaptation, there are two notable measures being undertaken within the initiative that facilitate climate change adaptation—the Indigenous Emissions Trading Program and the Reef Rescue package (see 'Coastal zones' below).

The Australian Government, through Parks Australia, is currently developing a climate change adaptation and mitigation strategy to aid in the development of specific programs and policies for the National Reserve System. These policies and programs will initially focus on three key reserves—Kakadu, the Australian National Botanic Gardens and Booderee National Park—to provide the support needed for them to adapt to the impacts of climate change.

In November 2008, the Council of Heads of Australia's Botanic Gardens released the *National Strategy and Action Plan for the Role of Australia's Botanic Gardens in Adapting to Climate Change*. This document sets out overall strategies and specific actions necessary to promote and resource Australia's botanic gardens in their vital role as facilitators of climate change preparedness and adaptation.

The Victorian Government released the Green Paper *Land and Biodiversity in a Time of Climate Change* in April 2008. The White Paper (currently under development) will help strengthen resilience of key natural assets to climate change by setting the direction for Victorian Government policy and investment priorities in natural resource management, land health and biodiversity for the next 20 to 50 years.

The New South Wales Government has released the *New South Wales Biodiversity and Climate Change Adaptation Framework* and nine regional *Climate Change Impact Profiles* with information tailored for decision makers in 13 catchment management authority regions.

In 2009, the Queensland Government announced a Climate Change Corridors for Biodiversity initiative to protect and manage landscape corridors by purchasing areas of high-potential biodiversity value and restoring vegetation. The goal of the initiative is to expand the protected area estate to 20 million hectares by 2020.

In May 2009, the Northern Territory Government announced funding of $600 000 for the Arafura to Alice Eco-Link, which will maintain major

landscape connectivity to enable movement of native plants and animals to areas with more favourable climatic conditions.

An expanded land and marine park network and increased off-reserve conservation efforts by the Northern Territory Government will provide more options for managing the impacts of climate change, both within larger reserves that provide a wider array of conditions and in new, closer reserves that better sample the full range of climatic variation, and so better resist species losses.

The Australian Capital Territory Government under its Weathering the Change climate strategy is developing an ecosystem connectivity map to better understand the impact of changes to rainfall and temperature patterns and soil type on species and ecosystems.

Coastal zones

The Australian Government provided $8.9 million, as part of its Climate Change Adaptation Program, to fund the Great Barrier Reef Climate Change Action Plan, a five-year program designed to develop and test strategies that will give the Great Barrier Reef, and those who depend upon it, the best chance of coping with climate change. The plan identifies strategies for direct actions and partnerships that will increase the resilience of the Great Barrier Reef to climate change. It focuses on actions that can be taken to help minimise impacts on the Reef's ecosystem, industries such as tourism, commercial and recreational fishing, and regional communities.

The Australian Government's $200 million Reef Rescue package aims to reduce the decline in water quality in the Great Barrier Reef by providing assistance to land managers in the Reef's catchments to accelerate the take-up of improved land management practices. These improved practices are aimed at reducing the run-off of nutrients, pesticides and sediments. This will improve the health and resilience of the Reef and its ability to cope with, and adapt to, the impacts of climate change.

The Australian Government is supporting a number of research programs into the impacts of climate change on coastal zones, including research undertaken by the Australian Institute of Marine Science into the impacts of climate change on tropical marine ecosystems, with a particular focus on tropical coral reefs. Activities are based on field, laboratory and modelling studies relating to observed and projected impacts of climate change and resilience of the Reef.

The New South Wales Government released the NSW Policy Statement on Sea Level Rise in November 2009. The statement specifies sea-level planning benchmarks for the NSW coastline—an increase above 1990 mean sea levels of 40 centimetres by 2050 and 90 centimetres by 2100. The statement also outlines the support that the government will provide to coastal communities and local councils to prepare for and adapt to rising sea levels.

The 2008 Victorian Coastal Strategy provides a long-term vision for the planning, management and sustainable use of Victoria's coast, and the policies and actions that will need to be implemented over the next five years to help achieve that vision. The strategy identifies and responds to significant issues affecting Victoria's coasts, including adapting to the risks and impacts of climate change.

The strategy contains a range of policies and actions, including the application of the precautionary principle to planning and management decision making when considering the risks associated with climate change. The strategy implements a policy benchmark of planning for sea-level rise of not less than 0.8 metres by 2100, until national benchmarks for coastal vulnerability are established.

The Queensland Government is working jointly with the Great Barrier Reef Marine Park Authority to implement measures for improving coordination and collaboration between governments and other partners in improving water quality for the Reef, including through the Reef Water Quality Protection Plan and the Reef Water Quality Partnership.

The Queensland Government has committed $175 million over five years to address water quality issues in the reef lagoon and will introduce new legislation to restrict the level and type of pesticides permitted to run off into waterways flowing to the Great Barrier Reef, and damaging farm practices.

The South Australian Government's Coast Protection Board is undertaking a review of policies in relation to new land development and sea-level rise. The review is expected to be completed by the end of 2009.

In 2009, the Tasmanian Government commenced a review of the State Coast Policy, which addresses the management and sustainable development of Tasmania's coast, in order to include requirements related to natural hazards in the coastal zone.

The City of Thuringowa (Queensland), together with James Cook University, has commenced an investigation of the impacts of sea-level rise, coastal erosion and storm surge on their coastal communities.

Adaptation options envisaged to arise from this work include new ways of upgrading infrastructure, improved spatial planning of new development, and more resilient building and construction methods.

In Queensland, the Gold Coast City Council has commissioned CSIRO to conduct a detailed modelling assessment to estimate potential sea-level rise in the region to 2070 to underpin future planning.

Settlements and infrastructure

The Australian Government initiated a $1.5 million Integrated Assessment of Human Settlements program in 2006 to enhance the capacity of local governments to identify climate change risks and develop responses. This program consisted of five national research projects around Australia—Western Port (Victoria), Sydney Coastal Councils (New South Wales), Clarence City (Tasmania), Gold Coast (Queensland) and a separate broader project focusing on Bendigo, Cooma, Queanbeyan/Australian Capital Territory and Darwin. All projects have been completed. The New South Wales, Victorian, Queensland, Tasmanian, Australian Capital Territory and Northern Territory governments and a number of local government bodies were partners to these projects.

Many of these projects identify high levels of present-day risk from climate change impacts. The risks are likely to increase under future climate change scenarios. The projects suggest that more work is needed on current planning policies, legislation and decision-making processes to keep pace with our emerging understanding of climate change.

The project outcomes have been instrumental in assisting local governments to prepare for and respond to climate change impacts. As a result of the Clarence City Council project, for example, the council is undertaking a range of work including nourishment and revegetation of beaches and dune areas, community education and awareness activities, and the introduction of new standards and planning controls.

Through the Local Government and Planning Ministers' Council, Australian governments have agreed to develop state-specific climate change planning policies to inform local governments and regional planning responses to climate change by mid-2011. The council has also agreed to develop a national framework and tools for use by local government to inform planning for climate change mitigation and adaptation.

The Australian Government is currently developing a national urban policy, which will articulate shared aspirations for Australia's cities and propose specific actions to improve the environmental sustainability, liveability and productivity of major cities.
The Australian Government is providing a more coordinated and integrated approach to the planning and infrastructure needs of major cities, through Infrastructure Australia and the Major Cities Unit of the Department of Infrastructure, Transport, Regional Development and Local Government.

In 2007, the Australian Government published *An Assessment of the Need to Adapt Buildings to the Unavoidable Consequences of Climate Change*. This study was a first step in examining the capacity of Australia's building stock and building practices to adapt to climate change. The Australian Building Codes Board has since commenced an investigation into possible modifications to the Building Code of Australia that take into account adaptation measures for climate change. This review will outline the major risks from climate change to Australia's building stock, investigate required nationally consistent or state-specific responses, and identify areas for further research. The review will also help ensure that building codes take potential future effects of climate change into account.

The Victorian Government undertook a preliminary study on infrastructure and climate change risk assessment to examine the potential risks from climate change impacts to the state's key infrastructure areas such as water, power, telecommunications, transport and buildings. The report, *Climate Change and Infrastructure—Planning Ahead*, was released in 2007.

The Western Australian Government is reviewing its State Planning Policy 2.6—State Coastal Policy, to ensure the policy basis is comprehensive, accurate and based on the best available information on the current status and trends of coastal policy and planning, which should be taken into account in planning and decision making. The review will include guidelines for determining an adequate coastal processes setback.

The Tasmanian Government's Adaptation to Natural Hazards through Land Use Planning project, begun in 2009, will improve the clarity and consistency of advice and direction given to local government, and others, on the mitigation of natural hazards through appropriate planning controls and development decisions. It will also consider acceptable risk thresholds in relation to planning.

CLARENCE CITY COUNCIL, TASMANIA

The Clarence City Council initiated a study of climate change impacts on Clarence coastal areas in south-east Tasmania in response to council and community concerns about erosion of beaches and flooding events in coastal areas. The project was supported by the Australian Government and the Tasmanian State Emergency Service.

The purpose of the study was to provide an assessment of climate change risks on coastal areas in Clarence City Council. Activities included:

- consultation with community groups, institutions and state government agencies on their awareness of and response to climate change issues
- assessment of 18 localities and infrastructure in Clarence City, which may be vulnerable to coastal hazards due to sea-level rise and climate change now and into the future
- investigation of adaptive management options in response to present and future coastal hazards
- preparation and execution of a communication plan to inform the community of the findings, initiate discussion about the preferred response and report on the community response.

Consultation with community groups revealed that Clarence residents were aware of and concerned about climate change and sea-level rise, but the extent to which they may be directly affected was not well understood. A significant theme was a desire to retain beaches in their current state.

The vulnerability assessment identified a number of localities and roads at risk now and in the medium term (25–75 years) from storm surge.

Recommended practical adaptive responses include:

- planning controls for new development
- physical works such as seawalls, groynes, dune management or sand nourishment, offshore breakwaters and/or surfing reefs, temporary or permanent flood barriers and reconstruction of public infrastructure above flood level
- detailed emergency management and evacuation planning with hazard reduction requirements for affected properties
- providing community education and information to improve awareness and ability to cope
- ongoing monitoring, analysis and review of findings.

The report gives Clarence City Council the basis to respond to the impacts of storm surge, erosion, inundation and sea-level rise in the short and long term. The council is undertaking a range of work, including adding more sand to, and working to revegetate, beaches and dune areas; raising and reinforcing some roads; installing effective sewerage systems; and developing new standards and planning controls.

Emergency management

In October 2009, the Australian Government released *Climate Change and Emergency Management: National Adaptation Research Plan*, which identifies critical gaps in the information needed by decision makers in the emergency management sector, sets research priorities based on those gaps, and identifies capacity that could be harnessed to conduct priority research. At the same time, the Government also announced grants totalling $2 million to address identified research priorities in emergency management.

In late 2008, the Ministerial Council for Police and Emergency Management – Emergency Management unanimously agreed that the future direction for Australian emergency management should be based on creating a more disaster-resilient Australia through (among other things) the development of climate change adaptation strategies for the emergency management sector. The Climate Change Adaptation Action Plan was endorsed by the council in November 2009.

The plan, developed in consultation with jurisdictional emergency management agencies, includes strategies to assist the emergency management sector to adapt to

the impacts of climate change as they directly affect the sector.

The Queensland Government has a number of initiatives (totalling nearly $29 million) to prepare Queensland to adapt to the impacts of projected increases in extreme events due to a changing climate. These initiatives will strengthen preparedness and response capacity and provide additional resources to the State Emergency Service and Rural Fire Service, as well as the community, including remote Indigenous communities.

Agriculture

The Australian Government is currently conducting a comprehensive national review of drought policy in recognition that the current arrangements may no longer be the most appropriate in the context of a changing climate. The review, which includes three separate assessments of the climatic, social and economic aspects of drought and drought support, will support the development of policies to help farmers and rural communities prepare for and adapt to a changing climate.

The Australian Government's Australia's Farming Future initiative has four components—the Climate Change Research Program, FarmReady, Community Networks and Capacity Building, and the Climate Change Adjustment Program.

The $46.2 million Climate Change Research Program on climate change adaptation includes a component in the agricultural sector. The program funds research and on-farm demonstration projects to help prepare Australia's primary industries for climate change and build resilience through practical management solutions for farmers and industries.

The FarmReady program aims to improve adoption of risk management and business management skills, and increase adoption of new technologies and best practice management so that primary producers, Indigenous land managers and agricultural industries can better adapt and respond to the impacts of climate change.

Community Networks and Capacity Building will build on the leadership and representative capacity of women, youth, Indigenous Australians and people from culturally and linguistically diverse backgrounds to strengthen community resilience and the productivity of primary industries.

The Climate Change Adjustment Program is assisting low-income, low-asset farmers who may be affected by climate change, including those experiencing financial hardship caused by drought.

In 2008, the Victorian Government released its Future Farming Strategy—a four-year program including $5.2 million in funding to enable farm businesses to plan for climate change.

In 2009, the Queensland Government announced an investment of $3.2 million to partner with industry stakeholders to support research to generate information and develop tools to help primary producers manage climate change risks and take advantage of emerging opportunities.

The South Australian Government's Research and Development Institute completed a study, funded by the Grape and Wine Research and Development Corporation, on the effects of extreme heat on the state's wine industry.

Fisheries

The Australian Government is developing a National Climate Change Action Plan for Fisheries and Aquaculture to inform and support effective climate change responses in the Australian aquaculture and wild catch (commercial, recreational and traditional) fishing sectors. The plan will provide a broad, principles-based response framework that promotes the incorporation of climate change considerations into decision making.

The Western Australian Government's Risk Assessment of Freshwater Fisheries in South-West of Western Australia project is currently under way; the final report is due for release in late 2009.

Forestry

The Australian Government has committed $8 million to assist Australian forest industries to prepare for the impacts of climate change. The Preparing Forest Industries for Climate Change initiative will address major knowledge gaps about the impact of climate change on forest industries.

The Australian Government is currently developing the National Climate Change and Commercial Forestry Action Plan in collaboration with key stakeholders to assist the forestry sector to respond to climate change through adaptation and mitigation.

Tourism

In July 2009, the Tourism Ministers' Council endorsed Tourism and Climate Change: A Framework for Action. The framework, developed in partnership

with governments, industry leaders and tourism researchers, aims to prepare the tourism industry to build its resilience and capacity to adapt to climate change impacts and to prepare for a carbon-constrained future.

In August 2009, the Sustainable Tourism Cooperative Research Centre released a scoping study, *The Impacts of Climate Change on Australian Tourism Destinations: Developing adaptation and response strategies*. Five key tourist destinations—Kakadu National Park, the Cairns region (including the Great Barrier Reef and Wet Tropics rainforest), Blue Mountains, Barossa Valley and Victorian Alps—were chosen as case study destinations. The study identified the challenges and opportunities for tourism destinations and strategies and actions to be implemented by industry, governments and the community.

The Great Barrier Reef Tourism Climate Change Action Strategy 2009–2012, released in August 2009, complements the Great Barrier Reef Marine Park Authority's Climate Change Action Plan 2007–2012 through tourism-specific projects. The strategy provides a way forward for the Reef's tourism industry as it faces a future impacted by climate change, and helps protect and improve the health and resilience of the Reef.

Human health

In December 2008, the Australian Government released *Human Health and Climate Change: National Adaptation Research Plan*, which identifies critical gaps in the information needed by decision makers in the health sector, sets research priorities based on those gaps, and identifies capacity that could be harnessed to conduct priority research.

The Australian Government identified health and climate change as a strategic priority for research in 2008 through three of its key research organisations—the National Health and Medical Research Council (NHMRC), CSIRO and the National Climate Change Adaptation Research Facility.

The NHMRC has funded a $4 million NHMRC Research Fellowship to the Australian National University's National Centre for Epidemiology and Population Health, to build a research program on human health and climate change.

The NHMRC has identified the health consequences of climate change as one of ten major health issues for the 2010–2012 triennium. The council will focus on the relevant research, health advice and ethical issues.

In December 2008, the Australian Government announced an investment of $10 million over a period of four years for research in health and climate change. This investment included $4 million to establish the CSIRO Collaboration Cluster on Urbanism, Climate Adaptation and Health to develop ways to reduce the impact of climate change on the health of Australia's urban population, and $6 million for addressing research priorities identified through the National Adaptation Research Plan for human health.

The New South Wales Government is piloting model heatwave action plans at the area health service level to prepare for the impacts of climate change.

In 2007, the Victorian Government released *Climate Change and Health: An exploration of challenges for public health in Victoria*, an initiative under its Climate Change Adaptation Program.

The Western Australian Government released the report *Health Impacts of Climate Change: Adaptation Strategies for Western Australia* in 2007. The report identifies potential health impacts from a given projected set of future environmental conditions; considers current coping capacity; identifies health-related vulnerabilities of people, regions, infrastructure and the economy; assesses the risks of the health impacts on communities, including specific reference to vulnerability; and develops adaptation measures to mitigate the identified impacts.

The Queensland Government undertook a review of the Queensland Heat Stress Response Plan in 2004 to ensure its adequacy to address risks posed by climate change. The Government is funding two projects in partnership with the Queensland University of Technology to evaluate the environmental health risk of heatwaves associated with global warming and to develop a framework for assessing the vulnerability of eco-environmental health to climate change. It is also developing a draft collaborative mosquito management plans with local government.

Water resources

The Australian Government is undertaking measures to facilitate adaptation to climate change through the $12.9 billion Water for the Future program. These measures are largely driven by the National Water Initiative, an initiative of the Council of Australian Governments, which is a blueprint for water reform in Australia. The Water for the Future measures are based on four key priorities: taking action on climate change, using water wisely, securing water supplies

and supporting healthy rivers. Measures under the program include the following:

- The $450 million Improving Water Information Program, carried out by the Bureau of Meteorology, will build the scientific and technical expertise to understand how much water Australia's river and groundwater systems are capable of providing into the future. This information will be vital in informing adaptation planning and responses.
- The $5.8 billion Sustainable Rural Water Use and Infrastructure Program is designed to improve key irrigation infrastructure in order to minimise system losses and enhance water use efficiency in rural areas of Australia.
- The $205.6 million National Rainwater and Greywater Initiative is designed to help families invest in saving water at home by installing rainwater tanks and greywater systems.
- The $261 million National Water Security Plan for Cities and Towns Program is providing funding to cities and towns with fewer than 50 000 people to upgrade older water systems with more efficient systems and technology, install new infrastructure and support practical projects that save water or reduce water losses.
- The $1 billion National Urban Water and Desalination Plan allows for investment in desalination plants, recycling schemes and stormwater projects to secure water supplies.
- The $3.1 billion Restoring the Balance in the Murray–Darling Basin Program allows the Australian Government to buy back water entitlements from willing sellers to improve the health of the Basin's rivers, wetlands and floodplains. Reducing the pressure on the Basin's high-value environmental assets from unsustainable levels of extraction (for example, for irrigation purposes) will support the Basin as water availability declines due to the effects of climate change.

The Australian and New South Wales governments are contributing to a comprehensive series of research projects to provide insight into the potential impacts of climate variability and climate change on Sydney's water supply and future demand for water. The project aims to provide an explanation of the drivers that influence Sydney's climate and rainfall and the implications for future runoff, water supply and demand. Researchers have developed a water demand model that links historical water use volumes with climate data from relevant weather stations. Water demand is most sensitive to changes in evaporation, followed by changes to temperature and rainfall. One of the key results of this project is that, over the long term, the low inflows into Sydney catchments (1991 to date) are without precedent since records began in 1909. It is probable that these low inflows are due to increased temperature and evaporation, and even if rainfall in Sydney does not change significantly there will be reductions in runoff and water availability for Sydney.

The New South Wales Government has released a metropolitan water plan that outlines the mix of measures essential to ensuring that Sydney's water needs are met in response to drought, a changing climate and the medium-term needs of a growing population.

The Victorian Government's Water Plan provides water security for Victoria in the face of reduced rainfall and runoff due to climate change and persistent dry conditions. The plan will diversify and boost water supplies in Melbourne, network the state's water resources, and enable a rapid and flexible response to changing future water needs.

The Western Australian Government and the WA Water Corporation are implementing the Western Australian Water Efficiency Measures, which include sprinkler restrictions and water-wise education initiatives for homes, businesses, schools and gardens. The Water Corporation is constructing desalination plants to supplement Western Australia's water supplies to reduce the reliance on climate-dependent water sources.

Local and regional planning

Through the Local Adaptation Pathways program, the Australian Government is providing funding to help local government bodies undertake climate change risk assessments and develop actions to prepare for the likely local impacts of climate change.

Ninety local governments received funding totalling $2.4 million. The funding will help councils integrate climate change risk assessment into their broader decision-making processes.

The following publications have been released by the Australian Government to support local government bodies in their efforts to adapt to the impacts of climate change:

- *Climate Change Adaptation Actions for Local Government* (2009), which identified climate change adaptation actions that are applicable to

Australia's climatic conditions and climate impact risks as currently projected (using CSIRO's 2007 climate change scenarios) and that can be implemented by Australian local governments.

- *Climate Change Impacts and Risk Management: A guide for business and government* (2007), which provides a framework for managing the increased risk to organisations due to climate change impacts. Its prime focus is on the initial assessment and prioritisation of these risks.

In 2009, the Queensland Government announced an investment of $800 000 to work with local government to ensure greenhouse gas reduction and climate change adaptation considerations are addressed in applications for state government grants for new infrastructure.

The Australian Local Government Association continues to work collaboratively with other levels of government and the community to address disaster mitigation, and assess and address the implications of climate change on councils' planning and development responsibilities, including work on coastal sea rise.

The Municipal Association of Victoria, with support from the Victorian Government, has undertaken a case study report on local government activities in greenhouse gas emissions abatement and climate change adaptation.

The South Australian Local Government Association has developed the Local Government Climate Change Strategy 2008–2012, which sets out a strategic approach to climate change over the next five years.

The Local Government Association of Queensland has released a Climate Change Management Strategy to provide a model process that local government bodies can use to develop a response to climate change issues.

Tools and support for adaptation planning

During the reporting period, the Australian Government has invested in developing tools to assist decision makers in understanding and managing the risks associated with climate change in vulnerable sectors, regions and communities.

A software tool is being developed by Geoscience Australia to evaluate the current vulnerability of buildings to severe winds and the costs and benefits of retrofitting older buildings. The tool simulates damage scenarios for buildings from component failures and water ingress and captures the variability that exists between buildings.

The Institute of Engineers, with Australian Government funding, has commissioned stage 1 of a three-stage revision of the *Australian Rainfall and Runoff Handbook* with a major focus on the potential impacts of climate change. The handbook is an essential design guide for engineers, architects and planners. The revised handbook will incorporate new data as well as technical and scientific advances in hydrology engineering to account for the potential effects of climate change on water resources, infrastructure planning, flood prediction and emergency management.

Other tools under development by the Australian Government include:

- a web-based tool that will enable planners, engineers and decision makers across Australia to incorporate projections of high sea-level events and their planning codes into adaptation measures
- a tool to project how climate change affects variation in offshore wave characteristics by combining climate modelling and spectral wave modelling
- the *Local Government Climate Change Adaptation Toolkit*, which outlines an adaptive management process and provides a set of tools and exercises to assist local government bodies as they work through the process of identifying risks and developing an adaptation action plan.

In 2009, the Australian Government, in collaboration with CSIRO, conducted an adaptation benchmarking survey to analyse adaptation activities in governments and industry sectors. The survey measures awareness, identifies current policies and programs relating to climate change as well as barriers to effective adaptation, and measures stakeholder relationships and future planning.

The Australian Government is providing grants to 12 professional associations, training organisations and tertiary institutions to integrate climate change implications into education and training for professionals, such as engineers, architects, planners and natural resource managers, who would be involved in planned adaptive responses to the impacts of climate change.

The New South Wales Government has initiated the development of tools and guidance for natural resource management, agriculture and planning

systems, and communities to better prepare for climate change and future climate variability. This work includes the Climatology in Agriculture project, which delivers climate risk management training through an accredited training workshop.

The New South Wales Government released three coastal planning documents for public comment in 2009: the *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*, which provides direction to councils when preparing planning instruments for coastal areas and assessing development proposals, and the *Coastal Risk Management Guide* and *Flood Risk Management Guide*, which advise councils on how to factor in sea-level rise benchmarks when calculating potential coastal hazard risks and flood risks.

The New South Wales Local Government and Shires Association has produced a web-based *Climate Change Action Pack* to support local government bodies in addressing the challenges arising from climate change by enhancing their understanding of the impact of climate change on their areas of responsibility and assisting them in mitigation and adaptation actions.

The Tasmanian Local Government Association has focused on providing access to tools and information on climate change through a website and conducting conferences, while the Queensland Local Government Association and the Western Australian Local Government Association have produced comprehensive tools and guides for local government bodies on adapting to climate change.

References

ABS (Australian Bureau of Statistics) 2008, *Australia at a Glance 2008: Yearbook Australia*, cat. no. 1309.0, ABS, Canberra.

—— 2009, *Land Management and Farming in Australia 2007–08*, cat. no. 4627.0, ABS, Canberra.

Antarctic Climate & Ecosystems Cooperative Research Centre 2008, *Position Analysis: Climate change, sea-level rise and extreme events: impacts and adaptation issues*.

Australian National University 2009, *Implications of Climate Change for Australia's World Heritage Properties: A preliminary assessment*, report to the Department of Climate Change and the Department of the Environment, Water, Heritage and the Arts.

Cai, W & Cowan, T 2006, 'SAM and regional rainfall in IPCC AR4 models: can anthropogenic forcing account for southwest Western Australian winter rainfall reduction?' *Geophysical Research Letters* 33, L24708, doi:10.1029/2006GL028037.

CSIRO (Commonwealth Scientific and Industrial Research Organisation) 2008, *Water Availability in the Murray-Darling Basin*, summary of a report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project.

CSIRO & BoM (Bureau of Meteorology) 2007, *Climate Change in Australia: Technical report 2007*, CSIRO, Melbourne.

eWater CRC n.d., *Ecological Aspects of Stream Recovery after Bushfire*, Bushfires and Catchments website, available at www.ewatercrc.com.au/bushfire/background_aspect.shtml.

Garnaut Climate Change Review 2008a, *The Implications for Irrigation in the Murray–Darling Basin*, report prepared by J Quiggin, D Adamson, P Schrobback & S Chambers.

—— 2008b, *Impacts of Climate Change on Infrastructure in Australia and CGE Model Inputs*, report prepared by Maunsell Australia Pty Ltd in association with CSIRO Sustainable Ecosystems.

—— 2008c, *Modelling the Costs of Unmitigated Climate Change*, technical paper no. 5, available at www.garnautreview.org.au.

—— 2000d, *Defining the Impacts of Climate Change on Horticulture in Australia*, report prepared by P Deuter.

—— 2008e, *The Impact of Climate Change and Ocean Acidification on the Great Barrier Reef and Its Tourist Industry*, report prepared by O Hoegh-Guldberg & H Hoegh-Guldberg.

—— 2008f, *The Impacts of Climate Change on Three Health Outcomes: Temperature-related mortality and hospitalisations, salmonellosis and other bacterial gastroenteritis, and population at risk from dengue*, report prepared by H Bambrick, K Dear, R Woodruff, I Hanigan & A McMichael.

—— 2008g, *Rural mental health impacts of climate change*, report prepared by H Berry, B Kelly, I Hanigan, J Coates, A McMichael, J Welsh & T Kjellstrom.

—— 2008h, *Climate Impacts on the Health of Remote Northern Australian Indigenous Communities*, report prepared by D Green.

Garnaut, R 2008, *The Garnaut Climate Change Review: Final report*, Cambridge University Press, Melbourne.

Gunasekera, D, Tulloh, C, Ford, M & Heyhoe, E 2008, *Climate Change: Opportunities and challenges in Australian agriculture*, Proceedings of Faculty of Agriculture, Food & Natural Resources Annual Symposium, 13 June 2008, University of Sydney.

Hennessy, K, Whetton, P, Smith, I, Bathols, J, Hutchinson, M & Sharples, J 2003, *The Impact of Climate Change on Snow Conditions in Mainland Australia*, CSIRO Atmospheric Research.

IPCC (Intergovernmental Panel on Climate Change) 2007a, *Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor & HL Miller (eds), Cambridge University Press, Cambridge.

—— 2007b, *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ML Parry, OF Canziani, JP Palutikof, PJ van der Linden & CE Hanson (eds), Cambridge University Press, Cambridge.

Steffen, W, Burbidge, AA, Hughes, L, Kitching, R, Lindenmayer, D, Musgrave, W, Stafford Smith, M & Werner, P 2009, *Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change*, report to the Natural Resource Management Ministerial Council commissioned by the Australian Government, CSIRO Publishing.

Victorian Government Department of Human Services 2009, *January 2009 Heatwave in Victoria: An assessment of health impacts*, State of Victoria.

CHAPTER 7

Financial resources and technology cooperation

KEY DEVELOPMENTS

Australia has provided a total of approximately $476 million of new and additional resources over five years (2005 to 2009) for climate change–related programs in developing countries. Approximately $30 million of this contribution has been provided to the Global Environment Facility for climate change activities.

Adaptation

Through the International Climate Change Adaptation Initiative, Australia is investing $150 million over three years (2008–09 to 2010–11) to meet high-priority climate adaptation needs in vulnerable countries in the Asia–Pacific region.

Mitigation and capacity building

Australia is investing $200 million over five years (2007–08 to 2011–12) in the International Forest Carbon Initiative, which aims to show that reducing emissions from deforestation and forest degradation in developing countries can be part of an equitable and effective post-2012 global climate change agreement.

Technology cooperation

In September 2008, the Australian Prime Minister announced the establishment of the Global Carbon Capture and Storage Institute and committed $400 million in funding over four years. The institute will help deliver the Group of Eight's goal of developing at least 20 fully integrated industrial-scale carbon capture and storage demonstration projects around the world. Carbon capture and storage represents a transitional technology, with the potential to make a substantial contribution to climate change mitigation by removing up to 90% of carbon emissions in a range of fossil fuel–based energy and industrial activities.

Australia is providing $100 million over three years (2008–09 to 2010–11) to support the World Bank Clean Technology Fund, which seeks to promote scaled-up financing for demonstration, deployment and transfer of low-carbon programs and projects with a significant potential for long-term greenhouse gas emissions savings.

Finance and technology are essential to support actions by all parties to achieve global emissions reductions consistent with stabilisation at or below 450 ppm and to adapt to the impacts of climate change we cannot avoid. Together with mitigation and adaptation, helping to shape a global solution is one of the three pillars of the Australian Government's climate change policy. The Australian Government is committed to helping other countries address climate change through the provision of finance, technology cooperation, capacity building and technical support.

Australia's approach to climate change financing and technology cooperation recognises that early action on both adaptation and mitigation will reduce global costs and the costs to individual countries. It also recognises that targeting support to build capacity in developing countries will enhance their ability to develop and implement domestic policies and measures, and increase access to international finance to support their efforts, including the carbon market.

The Australian Government will play its full and fair part in any contribution to international financing mechanisms agreed under the UNFCCC's post–2012 arrangements. In November 2009, the Australian Government announced its willingness to contribute its fair share to a Copenhagen Launch Fund, with 10% of Australian funding dedicated to small island developing states.

Many of Australia's adaptation, mitigation, capacity building and technology cooperation programs are administered through bilateral partnerships. However, a large proportion of Australia's climate change financing and technology cooperation is distributed through multilateral organisations including the Global Environment Facility and the World Bank.

Since 2005 Australia has provided approximately $476 million in new and additional funding for climate change–related programs in the areas of adaptation, mitigation, capacity building and technology cooperation to support climate change action in developing countries. Australia is assisting vulnerable communities to build resilience and to adapt to the impacts of climate change. Through its overseas programs, Australia is helping to bridge knowledge and finance gaps to support mitigation and adaptation in developing countries. This chapter provides an overview of Australia's multilateral and bilateral commitments and gives specific examples of adaptation, mitigation, capacity building and technology cooperation programs.

Australian financial transfer and technology cooperation programs with developing countries are managed by a number of government agencies. The Department of Climate Change is working closely with the Australian Agency for International Development, AusAID, which implements and manages a large number of climate change adaptation, mitigation, capacity building and technology cooperation programs, including with countries in the Asia–Pacific region. In addition, climate change programs and research in the fields of technology, transport, forestry, agriculture, waste management, coastal management and capacity building are managed by a number of other Australian government departments and research centres. These include the Department of the Environment, Water, Heritage and the Arts; the Department of Agriculture, Fisheries and Forestry; the Department of Resources, Energy and Tourism; the Commonwealth Scientific and Industrial Research Organisation (CSIRO); Geoscience Australia; the Bureau of Meteorology; and the Australian Centre for International Agricultural Research.

The Australian Government has taken steps to improve the quality and transparency of its reporting on financial and technology actions in the Fifth National Communication. One such step has been to improve the clarity of categories of assistance Australia has provided to developing countries. We look forward to working with other parties to the UNFCCC to further improve the quality and usefulness of National Communications, to reduce potential over-reporting and ensure that all efforts are captured and reported. The Australian Government would welcome further work in this area through the UNFCCC to establish and implement a definitive set of markers to facilitate and improve future National Communications.

There was a sharp increase in Australian financial assistance for climate change support in developing countries in 2007–08, reflecting the implementation of new Australian Government priorities.

7.1 Multilateral activities

Australia has made significant contributions to the United Nations and other international financial institutions that fund climate change adaptation, mitigation, capacity building and technology cooperation programs in developing countries. Australia believes that the support of multilateral institutions, such as the Global Environment Facility (GEF), the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC), is critical to ensuring support for climate change action in developing countries.

Details of Australia's contributions to the GEF and multilateral institutions and programs are set out in tables 7.1 and 7.2 respectively.

7.1.1 Global Environment Facility

The GEF is the mechanism for international cooperation dedicated to funding projects that protect the global environment and support sustainable development. Since Australia's Fourth National Communication on Climate Change, Australia has provided $91.4 million to the GEF Trust Fund, of which approximately $30.5 million has been targeted at climate change (see Table 7.1).

Working through the multilateral development banks, United Nations agencies and civil society organisations, the GEF delivers resources in all regions. The interim results of an independent Overall Performance Study (2009) show that the GEF has been instrumental in shaping developing countries' policy responses to environmental challenges and in achieving measurable outcomes such as greenhouse gas emission reductions (GEF Evaluation Office 2009).

7.1.2 Kyoto Protocol and UNFCCC

On 3 December 2007, Australia signed the instrument of ratification of the Kyoto Protocol, which came into effect on 11 March 2008. Australia is committed to taking strong action on climate change and is playing its part in the global effort to achieve an ambitious international outcome.

Australia, in accordance with its UNFCCC obligations, has contributed approximately $2.6 million to the core budget of the UNFCCC for the period 2004–05 to 2008–09.

Australia has made several voluntary contributions to the UNFCCC. Australia's contribution for the financial years 2004–05 to 2008–09 was approximately $1.8 million, which represents an increase of approximately $1.5 million since Australia's Fourth National Communication.

Australia has also provided $1.3 million to the UNFCCC Trust Fund for Participation since 2004. The purpose of the fund is to support the participation of poorer developing countries in the UNFCCC negotiations over the two years leading up to the 15th Conference of the Parties in Copenhagen in December 2009.

Other funds which Australia has committed directly for UNFCCC purposes include $0.28 million in 2008–09 for a UNFCCC technical paper (UNFCCC 2008) entitled *Mechanisms to Manage Financial Risks from Direct Impacts of Climate Change in Developing Countries*, which has been useful in informing post-2012 UNFCCC negotiations.

A complete set of figures for Australia's Kyoto Protocol and UNFCCC contributions can be found at Table 7.2.

7.1.3 Intergovernmental Panel on Climate Change

The IPCC is the leading body for the assessment of climate change and provides the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences. It is acknowledged by governments around the world, including the Australian Government, as the authoritative source of advice on climate change science.

Australia has provided funding to the IPCC for a range of activities, including participation by developing countries at IPCC meetings, workshops and capacity building activities. For the financial years 2004–05 to 2008–09, this assistance totalled approximately $0.34 million. Australia has provided substantial assistance to lead authors and editors of the IPCC technical and assessment reports.

Table 7.1 Australia's financial contributions to the Global Environment Facility, 2004–09 (USD million)

Global Environment Facility	2004–05[a]	2005–06[b]	2006–07[c]	2007–08[d]	2008–09[e]	Total
GEF replenishments*	13.40	11.35	15.00	17.65	14.68	**72.09**
One-third of which for climate change	**4.47**	**3.78**	**5.00**	**5.88**	**4.89**	**24.03**

* Assumptions: Actual monies disbursed.

a 2004–05—based on an average exchange rate of AUD 1 = USD 0.7524 (Source: Reserve Bank of Australia Statistics for 2003–2006).
b 2005–06—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2003–2006).
c 2006–07—based on an average exchange rate of AUD 1 = USD 0.7857 (Source: Reserve Bank of Australia Statistics for 2003–2006).
d 2007–08—based on an average exchange rate of AUD 1 = USD 0.8968 (Source: Reserve Bank of Australia Statistics for 2007–2009).
e 2008–09—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2007–2009).

Table 7.2 Australia's financial contributions to multilateral institutions and programs, 2004–09 (USD million)

Multilateral institution or program	2004–05[a]	2005–06[b]	2006–07[c]	2007–08[d]	2008–09[e]	Total
World Bank Group						
Climate Investment Fund—Clean Technology Fund	–	–	–	–	37.39	37.39
Climate Investment Fund—Pilot Program on Climate Resilience	–	–	–	–	19.39	19.39
Climate Investment Fund—Forest Investment Program	–	–	–	–	7.48	7.48
Energy Sector Management Assistance Program*	–	–	–	0.72	–	0.72
World Bank East Asia AusAID Infrastructure for Growth Single Donor Trust Fund—Energy component*	–	–	–	0.17	0.26	0.43
World Bank Forest Carbon Partnership Facility	–	–	–	11.70	–	11.70
Asian Development Bank						
Clean Energy Financing Partnership Facility	–	–	–	1.79	3.74	5.53
United Nations						
United Nations Framework Convention on Climate Change—Core	0.26	0.26	0.26	0.26	0.71	1.75
Least Developed Countries Fund	-	-	-	6.73	–	6.73
UNFCCC Trust Fund for Participation	0.02	0.07	0.08	0.94	0.18	1.28
UNFCCC—Technical paper	–	–	–	–	0.21	0.21
United Nations Environment Programme	0.41	0.41	0.47	0.72	0.67	2.69
Kyoto Protocol	–	–	–	–	0.50	0.50
Food and Agriculture Organization	–	–	–	–	0.07	0.07
Asia Pacific Seminar and Regional Workshop	0.03	–	–	–	–	0.03
Other						
Asia–Pacific Partnership on Clean Development and Climate	–	–	1.67	17.94	22.51	42.11
Global Carbon Capture and Storage Institute	–	–	–	–	65.05	65.05
Clean Technology Initiative	-	-	-	0.04	0.03	0.08
Intergovernmental Panel on Climate Change‡	0.07	0.07	0.07	0.07	0.20	0.49
Earth Negotiations Bulletin	–	–	–	0.03	0.09	0.12
Alliance of Small Island States	–	–	–	–	0.15	0.15
Secretariat of the Pacific Regional Environment Program†	1.09	1.05	1.10	1.32	1.08	5.65
Secretariat of the Pacific Community†	6.17	7.49	7.62	9.02	8.50	38.80
Secretariat of the Pacific Applied Geoscience Commission†	1.05	2.69	1.42	0.36	1.96	7.48
Total	**9.11**	**12.04**	**12.69**	**51.81**	**170.18**	**255.82**

* Showing only proportion of funding estimated for renewable energy or energy efficiency.

† A proportion of funding to these institutions is used for climate change related activities.

‡ Figures based on an average exchange rate, 2004–05: AUD 1 = CHF 0.9115; 2005–06: AUD 1 = CHF 0.9555.

a 2004–05—based on an average exchange rate of AUD 1 = USD 0.7524 (Source: Reserve Bank of Australia Statistics for 2003–2006).

b 2005–06—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2003–2006).

c 2006–07—based on an average exchange rate of AUD 1 = USD 0.7857 (Source: Reserve Bank of Australia Statistics for 2003–2006).

d 2007–08—based on an average exchange rate of AUD 1 = USD 0.8968 (Source: Reserve Bank of Australia Statistics for 2007–2009).

e 2008–09—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2007–2009).

7.1.4 World Bank Climate Investment Funds

Australia is also committed to engaging in multilateral financial mechanisms for climate change adaptation and technology cooperation. The multi-donor World Bank Climate Investment Funds are designed to test innovative ways to tackle climate change challenges and inform discussions within the UNFCCC.

Australia will provide $150 million to the Climate Investment Funds over three years (2008–09 to 2010–11). Of these funds, $100 million will support the Clean Technology Fund, and $50 million will support activities on adaptation and deforestation, which are funded through the International Climate Change Adaptation Initiative and the International Forest Carbon Initiative (see Table 7.2).

7.1.5 Least Developed Countries Fund

In 2007–08, Australia contributed $7.5 million to the Least Developed Countries Fund. The fund was established under the UNFCCC as part of a package of decisions to support least developed countries in their efforts to adapt to climate change, in acknowledgment of Article 4.9 of the Convention, which recognises the specific needs and special situations of least developed countries with regard to funding and transfer of technology. The fund is managed by the Global Environment Facility.

Specifically, the fund was designed to support least developed countries in identifying and addressing their 'urgent and immediate' adaptation needs, identified through the development of national adaptation programs of action. It is funded through voluntary donor contributions. As of May 2009, 19 countries (including Australia) had pledged a total of $236 million to the fund.

7.2 Bilateral and regional activities

Australia is working with bilateral partners on practical actions that contribute to the global effort to respond to climate change. Formal arrangements for bilateral cooperation are currently in place with China, the European Union, Indonesia, Japan, New Zealand, Papua New Guinea, South Africa, the United Kingdom and the United States.

The Australian Government provides funding to underpin practical climate change action through the **Bilateral Climate Change Partnerships Program**. The Government allocated $5.6 million between 2004 and 2008 and a further $0.8 million in 2009–10 specifically for developing and implementing bilateral partnerships and projects that deliver mutual practical benefit for Australia and partner countries. By connecting policy makers, scientists and researchers, these projects help build the capacity of developing countries to take action on climate change, including countries in the Asia–Pacific region.

7.3 Adaptation

Australia is committed to supporting adaptation in developing countries that are particularly vulnerable to climate change impacts. Recognising the particular vulnerability of small island developing states, the primary geographic emphasis of Australia's current adaptation assistance is on Pacific island countries and East Timor through the $150 million **International Climate Change Adaptation Initiative**.

Australia is also providing targeted policy and technical assistance, through multilateral institutions and bilateral partnerships, to assist developing countries in the region to adapt to the adverse effects of climate change. In addition, many of the disaster risk reduction activities which are supported by the Australian international development assistance program have clear climate change adaptation benefits. In 2008–09 alone, Australia provided over $40 million to improve disaster risk reduction in developing countries.

Details of Australia's contributions to bilateral and regional activities between 2004–05 and 2008–09 are set out in Table 7.3 ((i) to (v)).

7.3.1 International Climate Change Adaptation Initiative

The International Climate Change Adaptation Initiative (ICCAI) has four interrelated components, which in combination will deliver a coordinated package of development assistance:

1. improving scientific information on, and understanding of, climate change impacts
2. increasing the level of understanding of key climate vulnerabilities at the regional, national and sector levels
3. financing implementation of priority adaptation measures
4. contributing to multilateral financial mechanisms for climate change adaptation.

Under component one, Australia is investing $20 million (from 2008–11) to the Pacific Climate Change Science Program. The program will work closely with Pacific island countries and East Timor to provide decision makers with improved information on the likely impacts of climate change. It will help partner countries track climate trends, investigate regional climate drivers, provide regional climate projections, and improve understanding of ocean processes, ocean acidification and sea-level rise. Investment in improved climate change science will enhance the basis for making adaptation decisions and help target future development assistance.

Under component two, the $12 million Pacific Adaptation Strategy Assistance Program (PASAP), the ICCAI will provide assistance to partner countries in the Pacific and East Timor to assess key vulnerabilities and risks, formulate adaptation strategies and plans, and integrate adaptation into decision making. The PASAP will provide a framework for targeted training and capacity building for partner countries to develop climate change adaptation assessments and strategies focusing on particularly vulnerable sectors including water resources, food security, and coastal zone management.

Under component three, the ICCAI is providing bilateral and regional assistance to vulnerable countries in the Asia–Pacific region to identify and implement priority adaptation measures. Australia has committed $25 million (over 2009–11) in bilateral adaptation assistance to Pacific island countries and is providing funds ($2 million in 2008–09, and $4 million from 2009 to 2011) to the GEF's **Mekong and Asia–Pacific Community-based Adaptation Small Grants Program**. The program is providing small grants for implementation of priority adaptation measures at the local level in 15 Pacific island countries, the Mekong subregion, East Timor and Sri Lanka.

Australia also provided $0.5 million to the **South Asia Water Initiative** in 2008–09 (as part of a $3 million total commitment) to support scientific work to establish climate change scenarios for the river systems emanating from the Himalayan region and to enhance regional cooperation on key climate-affected water issues.

Australia is also providing assistance to the Government of Vietnam to assess key climate vulnerabilities in the Mekong Delta ($0.57 million in 2008–09 and $0.57 million in 2009–10).

The fourth component of the ICCAI will contribute $40 million, including $25.9 million in 2008–09, to the **Pilot Program on Climate Resilience**, one of the programs established under the World Bank Climate Investment Funds. The program will demonstrate how to integrate climate risks and resilience into countries' development planning through pilot projects. These projects are consistent with countries' own poverty reduction and sustainable development goals.

7.3.2 Climate change adaptation and preparedness in the Pacific

Work under the International Climate Change Adaptation Initiative builds on Australia's long-term engagement in climate monitoring and adaptation in the Pacific. Australia has supported the following regional programs with Pacific countries and regional organisations to guide local physical, social and economic planning and decision making:

- the **South Pacific Sea Level and Climate Monitoring Project** ($8.4 million from 2004 to 2009), providing data for Pacific island countries to help monitor climate change impacts on sea levels
- the **Pacific Islands Climate Prediction Project** ($4.0 million from 2004 to 2009), assisting national meteorological services in the Pacific to provide more accurate climate prediction services tailored to the needs of government and business
- the **Pacific Vulnerability and Adaptation Initiative** ($2.8 million from 2005 to 2009), funding community adaptation projects in Fiji, Samoa, Solomon Islands, Tonga and Vanuatu and enhancing water catchment and storage facilities in Tuvalu.

Australia is also co-financing the World Bank–implemented **Kiribati Adaptation Project Phase II** (the Australian contribution is $2.9 million from 2006 to 2009). Australia's contribution is assisting to upgrade water supply infrastructure and improve freshwater resource management.

Australia is also supporting **Pacific regional organisations** working on climate change issues, including core funding and project support for the Secretariat of the Pacific Regional Environment Programme, the Pacific Islands Applied Geoscience Commission and the Secretariat of the Pacific Community.

Working with **universities and researchers** to better understand climate change impacts and adaptation options is another priority, with funds allocated through the Australian Development Research Awards ($2 million, 2007 to 2011) to support research aimed at building the capacity of developing countries to effectively respond to the impacts of climate change.

Table 7.3(i) ***Bilateral and regional financial contributions related to the implementation of the UNFCCC for the financial year 2004–05 (USD million)[a, b]***

Recipient country/ region	Mitigation							Adaptation				Total
	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Other	Capacity building	Coastal zone management	Other vulnerability assessments	Other	
China	0.32	–	–	–	–	–	–	–	–	–	–	**0.32**
Kiribati	–	–	–	–	–	–	–	–	–	–	1.51	**1.51**
Pacific—other	–	–	–	–	–	–	–	–	–	1.65	–	**1.65**
Total	**0.32**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**1.65**	**1.51**	**3.47**

a The Australian financial year is from 1 July to 30 June.

b 2004–05—based on an average exchange rate of AUD 1 = USD 0.7524 (Source: Reserve Bank of Australia Statistics for 2003–2006).

Table 7.3(ii) ***Bilateral and regional financial contributions related to the implementation of the UNFCCC for the financial year 2005–06 (USD million)[a, b]***

Recipient country/ region	Mitigation							Adaptation				Total
	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Other	Capacity building	Coastal zone management	Other vulnerability assessments	Other	
China	0.32	–	–	–	–	–	–	–	–	–	–	**0.32**
Kiribati	–	–	–	–	–	–	–	–	–	–	0.69	**0.69**
Pacific—other	–	–	–	–	–	–	–	–	–	2.37	–	**2.37**
Solomon Islands	–	–	1.71	–	–	–	–	–	–	–	–	**1.71**
Total	**0.32**	**–**	**1.71**	**–**	**–**	**–**	**–**	**–**	**–**	**2.37**	**0.69**	**5.10**

a The Australian financial year is from 1 July to 30 June.

b 2005–06—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2003–2006).

Table 7.3(iii) ***Bilateral and regional financial contributions related to the implementation of the UNFCCC for the financial year 2006–07 (USD million)***[a, b]

Recipient country/ region	Mitigation							Adaptation				Cross-cutting	Total
	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Other	Capacity building	Coastal zone management	Other vulnerability assessments	Other		
Asia–Pacific	–	–	–	–	–	–	–	–	0.20	–	–	–	**0.20**
China	1.22	–	–	–	–	–	–	–	–	–	–	–	**1.22**
Global unspecified	–	–	0.02	–	–	–	–	–	–	–	–	1.18	**1.20**
Indonesia	–	–	–	–	–	–	–	–	–	–	–	0.16	**0.16**
Kiribati	–	–	–	–	–	–	–	–	–	–	0.01	–	**0.01**
Pacific—other	–	–	–	–	–	–	–	–	–	2.48	–	–	**2.48**
South Africa	–	–	–	–	–	–	–	–	–	0.07	–	–	**0.07**
Total	**1.22**	**–**	**0.02**	**–**	**–**	**–**	**–**	**–**	**0.20**	**2.55**	**0.01**	**1.33**	**5.33**

a The Australian financial year is from 1 July to 30 June.

b 2006–07—based on an average exchange rate of AUD 1 = USD 0.7857 (Source: Reserve Bank of Australia Statistics for 2003–2006).

Table 7.3(iv) ***Bilateral and regional financial contributions related to the implementation of the UNFCCC for the financial year 2007–08 (USD million)***[a, b]

Recipient country/ region	Mitigation							Adaptation				Cross-cutting	Total
	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Other	Capacity building	Coastal zone management	Other vulnerability assessments	Other		
Asia–Pacific	1.79	–	2.31	–	–	–	–	–	–	–	–	–	**4.10**
Cambodia	0.43	–	–	–	–	–	–	–	–	–	–	–	**0.43**
China	1.23	–	–	–	–	–	–	–	–	–	–	–	**1.23**
Global unspecified	–	–	11.55	–	–	–	–	–	–	–	1.57	6.91	**20.03**
India	–	–	–	–	–	–	–	–	–	0.04	–	–	**0.04**
Indonesia	0.09	–	2.66	–	–	–	0.35	–	–	–	–	1.20	**4.30**
Laos	1.36	–	–	–	–	–	–	–	–	–	–	–	**1.36**
Mekong	–	–	–	–	–	–	–	–	–	1.35	–	–	**1.35**
Pacific—other	1.35	–	–	–	–	–	–	–	–	3.55	0.09	–	**4.98**
Samoa	1.13	–	–	–	–	–	–	–	–	–	–	–	**1.13**
Solomon Islands	0.85	–	–	–	–	–	–	–	–	–	–	–	**0.85**
South Africa	–	–	–	–	–	–	0.04	–	–	–	–	–	**0.04**
Vanuatu	1.16	–	–	–	–	–	–	–	–	–	–	–	**1.16**
Vietnam	0.90	–	–	–	–	–	–	–	–	–	0.99	–	**1.88**
Total	**10.29**	**–**	**16.51**	**–**	**–**	**–**	**0.39**	**–**	**–**	**4.94**	**2.64**	**8.11**	**42.89**

a The Australian financial year is from 1 July to 30 June.

b 2007–08—based on an average exchange rate of AUD 1 = USD 0.8968 (Source: Reserve Bank of Australia Statistics for 2007–2009).

Table 7.3(v) ***Bilateral and regional financial contributions related to the implementation of the UNFCCC for the financial year 2008–09 (USD million)[a, b]***

Recipient country/ region	Mitigation							Adaptation				Cross-cutting	Total
	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Other	Capacity building	Coastal zone management	Other vulnerability assessments	Other		
Asia–Pacific	–	–	3.44	–	–	–	–	–	–	–	1.50	–	**4.94**
Cambodia	0.16	–	–	–	–	–	–	–	–	–	–	–	**0.16**
China	0.72	–	–	–	–	–	–	–	–	–	–	–	**0.72**
East Timor	–	–	–	–	–	–	–	–	–	–	0.19	–	**0.19**
Global unspecified	–	–	1.11	–	–	–	–	–	–	–	1.15	4.75	**7.02**
India	–	–	–	–	–	–	0.04	–	–	–	–	–	**0.04**
Indonesia	3.07	–	9.84	–	–	–	–	–	–	–	–	1.77	**14.67**
Kiribati	–	–	–	–	–	–	–	–	–	–	0.01	–	**0.01**
Laos	1.14	–	–	–	–	–	–	–	–	–	–	–	**1.14**
Pacific—other	–	–	–	–	–	–	–	–	–	2.05	0.10	1.53	**3.68**
Papua New Guinea	–	–	0.12	–	–	–	–	–	–	–	–	0.11	**0.24**
Samoa	3.09	–	–	–	–	–	–	–	–	–	–	–	**3.09**
South Africa	–	–	–	–	–	–	–	–	–	0.07	–	–	**0.07**
South Asia	–	–	–	–	–	–	–	–	–	–	0.37	–	**0.37**
Tuvalu	–	–	–	–	–	–	–	–	–	–	0.28	–	**0.28**
Vanuatu	0.02	–	–	–	–	–	–	–	–	–	–	–	**0.02**
Vietnam	–	–	–	–	–	–	–	–	–	0.43	0.75	–	**1.17**
Total	**8.19**	**–**	**14.52**	**–**	**–**	**–**	**0.04**	**–**	**–**	**2.55**	**4.34**	**8.16**	**37.79**

a The Australian financial year is from 1 July to 30 June.

b 2008–09—based on an average exchange rate of AUD 1 = USD 0.7477 (Source: Reserve Bank of Australia Statistics for 2007–2009).

Recent awards include assisting health and water sectors in the Asia–Pacific respond to increased climate risk ($0.29 million, 2009 to 2011); assisting the Pacific tourism sector to adapt to climate change ($0.39 million, 2009 to 2011); and trialling carbon offset schemes to fund mangrove rehabilitation in the Solomon Islands ($0.46 million, 2009 to 2011).

Australia is also supporting a new program of research which was initiated in 2007–08 to better position Australia and Mekong region partners to respond to climate change. The Mekong River Commission (MRC) and CSIRO, with funding of $0.48 million in 2007–08, undertook research on climate change vulnerability in the Lower Mekong Basin. The outputs of the research will be used to inform water resource availability scenarios to be formulated under the MRC Basin Development Plan.

This work is supported by a new project, the MRC Climate Change and Adaptation Initiative 2008–2012. By applying improved climate impact modelling and assessment in the lower Mekong Basin, this initiative aims to identify key vulnerabilities of communities to the impacts of climate change and to build appropriate responses. Australia provided $1.1 million to support development of this initiative in 2007–08, and has allocated $3 million over the period 2009–11 to fund the first phase of the initiative.

In addition, Australia is partnering with Germany's Gesellschaft fur Technische Zusammenarbeit (GTZ), a federally-owned international development enterprise, to support the Vietnam Conservation and Development of Key Sites of the Man and the Biosphere Reserve of Kien Giang Province program ($2.75 million from 2007–11). The core aims of the project are to preserve forests and coastlines vulnerable to climate change, conserve important biodiversity of the UNESCO biosphere in Kien Giang, and develop sustainable livelihood opportunities for the rural poor, particularly ethnic minorities, living in the target area.

7.4 Mitigation and capacity building

Building capacity in developing countries is critical to assist countries in mitigating against and managing the impacts of climate change. The Australian Government has committed resources to create enabling environments for private sector investment, strengthen institutional and regulatory frameworks, and to build capacity for developing countries to access global carbon markets and take on practical mitigation actions. Australia has established a number of pilot actions in developing countries which address these key mitigation and capacity building objectives.

7.4.1 Reducing emissions from deforestation and forest degradation in developing countries

Greenhouse gas emissions from deforestation comprise about 18% of global greenhouse gas emissions. Reducing emissions from deforestation and forest degradation in developing countries (REDD) is therefore a critical component of the global mitigation effort to address climate change. Australia believes that REDD can be part of an equitable and effective post-2012 international agreement on climate change.

For this reason, Australia has been actively engaged in the development of a robust and transparent REDD mechanism from an early stage.

For example, Australia co-hosted with New Zealand a UNFCCC workshop to discuss policy approaches on REDD in March 2007. The workshop played an important role in driving progress on REDD in the UNFCCC negotiations.

Australia also hosted the High-Level Meeting on Forests and Climate in Sydney in July 2007. The meeting brought together ministers and senior officials from 63 countries. Representatives from international organisations, as well as business, industry and environmental non-government organisations, also participated in the three-day event, which furthered efforts in establishing a robust and effective financial mechanism to assist developing countries on REDD.

International Forest Carbon Initiative

Central to Australia's recent engagement on REDD is the five-year (2007–08 to 2011–12), $200 million **International Forest Carbon Initiative** (the Initiative). The Initiative is supporting international REDD efforts through the UNFCCC and through bilateral projects aims to demonstrate that REDD can be part of an equitable and effective post-2012 international agreement on climate change.

Australia's cooperation with Indonesia under the Initiative

Under the Initiative, the Prime Minister of Australia and the President of Indonesia announced the **Indonesia–Australia Forest Carbon Partnership** on 13 June 2008. Indonesia has the third largest area of tropical forests in the world, but forest loss due to expanding populations, fire and conversion of forests for agriculture or plantations make Indonesia one of

the largest greenhouse gas emitters in the world. As measures to address REDD are not included in the Kyoto Protocol, Australia and Indonesia are now working together to demonstrate that REDD can and should be part of the next global climate change agreement.

The partnership is operating in three key areas: strategic policy dialogue on climate change; increasing Indonesia's carbon accounting capacity; and identifying and implementing incentive-based REDD demonstration activities.

Under the partnership, Australia is working with Indonesia to develop large-scale demonstration activities and to build Indonesia's ability to enter into future international forest carbon markets. Australia has committed $30 million over four years to the **Kalimantan Forests and Climate Partnership** (KFCP), the first large-scale REDD demonstration activity of its kind in Indonesia. The aim is to trial an innovative, market-oriented approach to financing and implementing measures for REDD on the degraded and forested peatland in Central Kalimantan. Australia and Indonesia have also agreed to develop a second REDD demonstration activity, which will differ from the KFCP in its location and forest type, to test different aspects of REDD.

Australia has also provided $10 million to support Indonesia's forest and climate policy development. This is being used to help develop the Indonesian National Carbon Accounting System, support the development of national policy frameworks and strategies for REDD, and better monitor, manage and prevent large-scale forest fires in Indonesia.

Australia's cooperation with Papua New Guinea under the Initiative

Australia is also working with Papua New Guinea on REDD. The Prime Minister of Australia and the Prime Minister of Papua New Guinea signed the **Papua New Guinea – Australia Forest Carbon Partnership** on 6 March 2008. The partnership is focused on cooperation in three key areas: strategic policy dialogue on climate change; carbon accounting capacity building; and REDD demonstration activities. In 2009 Australian assistance was focused on strategic policy dialogue on climate change in support of COP15.

Under the partnership, Australia has committed up to $3 million in initial funding which aims to build the capacity of institutions in Papua New Guinea to articulate and implement national climate change policies that meet relevant international standards; build the capacity of institutions to develop a robust national carbon monitoring and accounting system; and support Papua New Guinea to engage in international dialogue on REDD.

Australia's global activities under the Initiative

As part of the Initiative, a $3 million research partnership with the **Centre for International Forestry Research**, based in Indonesia, is helping meet the need for further global research on policy and technical issues associated with REDD. The research partnership will collect and disseminate lessons learned to inform the design and implementation of REDD activities.

Up to $1.5 million has been made available to support international non-government organisations (NGOs) to develop REDD demonstration activity ideas to the initial concept stage. This funding will help NGOs and their partners frame ideas in ways that will be relevant and useful to the countries in which the activities are proposed to take place. The funding aims to promote creativity, transparency, methodological rigour and, above all, foster better linkages between local initiatives and the national governments who must endorse them. International NGOs have practical on-the-ground experience, particularly in providing alternative livelihoods to local communities, which can help build global expertise in implementing demonstration activities.

The $15.8 million **Asia Pacific Forestry Skills and Capacity Building Program**, which also falls under the Initiative, is primarily assisting Indonesia and Papua New Guinea to increase their capacity to manage their forests sustainably to reduce emissions from deforestation and forest degradation. Funding of $2.3 million under the first phase of the program supported projects in Indonesia and Papua New Guinea, and other regional countries such as Vietnam and Fiji, on reduced impact logging, forest certification, restoration of degraded forests and research. The program's second phase will aim to build capacity for delivering sustainable forest management that supports REDD efforts. This second phase will fund between three and five longer-term, large-scale projects in Indonesia and Papua New Guinea.

Australia has provided $11.7 million to the World Bank's **Forest Carbon Partnership Facility**, which assists developing countries in their REDD efforts. The facility aims to build confidence in REDD investments by establishing early links between key rainforest countries and potential financiers, so that emissions reductions achieved by large-scale demonstration activities may be certified and the

associated credits sold. Australia has also provided $10 million to the Forest Investment Program, which will complement the Forest Carbon Partnership Facility by scaling-up REDD activities. This program is part of the broader Climate Investment Funds managed by the World Bank.

7.4.2 Capacity building

By connecting policy makers, scientists and researchers, the Australian Government is helping to build the capacity of developing countries to take action on climate change, including countries in the Asia–Pacific region.

Specific objectives include:

- undertaking practical actions that achieve or facilitate emissions reductions
- building capacity to enable implementation of mitigation and adaptation programs
- improving understanding of climate change impacts through improved scientific information
- building support for an effective global response to climate change
- facilitating market opportunities for low emissions technologies, products and expertise
- fostering direct involvement by industry, business, scientists and communities in projects to broaden participation in climate change action.

Capacity building for climate change research

Australia continues to provide significant technical advice and assistance to countries in the neighbouring Asia–Pacific region to improve climate data management and monitoring capabilities, for example through the PCCSP under component one of the ICCAI (discussed in 7.3.1). The PCCSP will work closely with Pacific island countries and East Timor to provide decision makers with improved information on the likely impacts of climate change. The $3 million Pacific Future Climate Leaders Program (2008–11), also under the ICCAI, will support the training of future Pacific climate change leaders through scholarships, exchange programs and community education.

Through the Pacific Islands Climate Prediction Project, Australia is enhancing the prudent use of information derived from climate prediction software in the meteorological services of ten Pacific island countries. Participating meteorological services can provide long range weather information, including predictions, to help decision-making processes of climate sensitive clients such as farmers, water resource managers and the tourism industry. The digitising of recovered historical weather records, and a monthly Pacific Islands Climate Outlook Forum coordinated by the Australian Bureau of Meteorology, are enhancing Pacific countries' ability to analyse climate trends. Australia is also providing data for Pacific island countries to help monitor climate change impacts on sea levels, through the South Pacific Sea Level and Climate Monitoring Project.

Further details on Australian assistance for climate change research can be found in Chapter 8. Chapter 9 contains information on how Australia is supporting research and leadership on climate change in developing countries.

Other support for Indonesian climate change action

In addition to assistance provided to Indonesia under Australia's International Forest Carbon Initiative, Australia has contributed to the establishment of Indonesia's financing framework for climate change and incorporation of climate change into economic and development planning.

In 2008–09, Australia made an initial $2 million contribution to the establishment of the Indonesia Climate Change Trust Fund. The government-led, donor-financed trust fund will finance implementation of Indonesia's national roadmap for climate change action.

Australia has helped prepare a draft Climate Change Green Paper with the Indonesian Ministry of Finance to provide economic and fiscal options for encouraging low-carbon development. Australia has also contributed $0.39 million (2007–08) to a study by the World Bank on low carbon development strategies which is guiding development planning.

Australia has provided $4 million (2007–08) to the Government of Indonesia's National Program for Community Empowerment to undertake a demonstration program of conditional transfers to communities for natural resource management and renewable energy (micro-hydro) projects in Sulawesi. Australia has also provided $1.5 million (2006–07 to 2008–09) to the World Bank and CSIRO for the Analysing Pathways to Sustainability project, which constructed computable general equilibrium and agent-based models for testing the economic, social and environmental—including climate—

consequences of macro and micro policy decisions, such as the impacts of fuel and energy subsidies. This work is contributing to Indonesia's low-carbon development planning.

7.5 Technology cooperation

Australia is actively participating in a range of international technology-based partnerships and programs. These initiatives are aimed at strengthening information networks, training, research and practical collaboration on climate change actions. A description of selected programs that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies can be found at Table 7.4.

7.5.1 Technology cooperation under the United Nations Framework Convention on Climate Change

Through the **UNFCCC Experts Group on Technology Transfer** (EGTT), Australia assists in providing strategic advice to the UNFCCC on technology issues and promotes information exchange on technology between Parties to the UNFCCC. Australia is currently Vice-Chair of EGTT and next year will assume the chair role for a one-year term.

Australia is engaged in a number of additional **plurilateral forums on technology** and is committed to securing an agreement under the UNFCCC that complements and supports the extensive current range of international and national technology-related initiatives, including work undertaken by the International Energy Agency, the Global Carbon Capture and Storage Institute, the Asia Pacific Partnership on Clean Development and Climate, and the World Bank's Clean Investment Framework.

7.5.2 Global Carbon Capture and Storage Institute

Australia has committed $100 million per annum to fund the Global Carbon Capture and Storage Institute (GCCSI) and a further $2.4 billion to build two to four industrial-scale carbon capture and storage projects in Australia under the Government's new Carbon Capture and Storage Flagships Program. The GCCSI was developed by the Australian Government to provide the conduit for the transfer of knowledge and know-how between governments and other organisations that are looking to further the development and deployment of carbon capture and storage technologies globally. The GCCSI will promote the collaboration of existing efforts and knowledge sharing.

The GCCSI aims to:

- draw together information, knowledge and expertise to build a much-needed central knowledge base
- play a pivotal role in facilitating the development and deployment of safe, economic and environmentally sustainable commercial-scale carbon capture and storage projects
- advise on the technologies that will capture, transport and store emissions, and provide expert insight on the costs and benefits of carbon solutions and the operational and legislative requirements needed to achieve success
- work collaboratively with governments, non-government bodies and the private sector to build confidence in carbon capture and storage and help drive international momentum.

The GCCSI will encourage and collaborate on smaller test beds of development and non-industrial-scale projects to nurture the development of second- and third-generation projects. Information from these projects will be disseminated to its members and the international carbon capture and storage community.

7.5.3 Cleaner development pathways

Australia's bilateral activities to promote less greenhouse intensive development pathways include investment in energy efficiency and renewable energy. Of the total energy program, an estimated $15.1 million has been allocated to energy efficiency and $5.2 million to renewable energy in 2007–08 and 2008–09. These activities focus predominantly on the Mekong and Pacific regions.

Examples of Australian support for energy are the **Rural Electrification and Transmission programs** in Laos and Cambodia, which are implemented by the World Bank. These programs support grid extensions, efficiency improvements in electricity transmission and off-grid energy systems such as solar photovoltaic and small-scale hydropower.

Australia is supporting the **Sustainable Energy Financing Project** in Solomon Islands, also implemented by the World Bank. This program assists communities and private entrepreneurs to access long-term financing for the purchase of solar panels, small-scale hydropower generators and equipment to allow use of biodiesel.

Table 7.4 ***Description of selected projects or programs that promoted practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies***

Pacific Islands Climate Prediction Project			
Purpose The aim of the Pacific Islands Climate Prediction Project (PI-CPP) is to expand and enhance the prudent use of information derived from climate prediction software into the meteorological services of ten Pacific Island countries. The software is based on the statistical operational system employed by the Australian Bureau of Meteorology (BoM) to produce seasonal climate forecasts for Australia. BoM is enabling Pacific meteorological services to provide climate information, including predictions, to help decision-making processes within stakeholder agencies of participating countries.			
Recipient countries	**Sector**	**Total funding**	**Years in operation**
Samoa, Papua New Guinea, Solomon Islands, Vanuatu, Kiribati, Tuvalu, Fiji, Tonga, Niue and Cook Islands	National meteorological services (NMSs)	$5.3 million for both phases ($3 million for Phase 2 only)	2005 to 2009

Description

The project has four parts:

- develop and install PC-based climate prediction software
- train NMS personnel in the use of the climate prediction software and the establishment of a climate prediction service
- facilitate linkages between NMS staff and clients making climate sensitive decisions
- train clients in the effective use of prediction information.

The uptake and effective use of the seasonal climate prediction information by key climate-sensitive sectors are fundamental to the success of the project.

Achieving this requires careful and comprehensive training so that both the benefits and limitations of the prediction information are clearly understood. Tailoring of prediction services to the specific needs of users in each country will also help ensure the optimal use of the predictions.

The benefits of climate predictions in practical situations relevant to Pacific countries are being demonstrated by a small number of pilot schemes. These will assist in developing industry-specific climate predictions and appropriate management responses. Virtually all training activities are carried out in-country.

Indicate factors which led to project's success

Since the PI-CPP was implemented in the beginning of 2005, the value of climate prediction information has been demonstrated through a number of pilot projects and demand for customised sector specific climate information has increased.

PI-CPP Phase 1 focused almost entirely on building capacity in NMSs to deliver generalised seasonal rainfall predictions. Phase 2 has seen greater engagement and development of partnerships between the NMSs and their clients/stakeholders, for the routine provision and uptake of customised predictions. The uptake of customised rainfall outlooks and their utilisation by specific climate-sensitive industries has been successfully demonstrated through a number of pilot projects initiated in Phase 2. There is considerable potential to extend projects to other islands and sectors.

PI-CPP has been successful in enhancing NMS understanding of the strengths and limitations of current seasonal prediction capabilities, enabling them to provide climate services with more confidence.

Technology transferred

- Provision of and training in climate prediction software, human resources development

Impact on greenhouse gas emissions/sinks (optional)

Not applicable

Table 7.4 ***(continued)***

Pacific Vulnerability and Adaptation Initiative			
Purpose The aim of this initiative is to enable Pacific island countries to adapt to the future impact of climate change, climate variability and sea-level rise. Consistent with the objectives of the Pacific Island Framework for Action on Climate Change, Climate Variability and Sea Level Rise, the initiative aims to contribute to adaptation at the community level.			
Recipient countries	**Sector**	**Total funding**	**Years in operation**
Tuvalu, Vanuatu, Fiji, Samoa, Solomon Islands and Tonga	Adaptation strategies	$2.8 million	2005 to 2009
Description The initiative is focused on funding community adaptation projects in Fiji, Samoa, Solomon Islands, Tonga and Vanuatu and enhancing water catchment and storage facilities in Tuvalu. **Indicate factors which led to project's success** The initiative has funded practical activities such as the replanting of coastal mangroves to protect shorelines, the construction of rainwater tanks on islands affected by seasonal drought, the trialling of versatile crop varieties and the recording of traditional knowledge about disaster preparation. **Technology transferred** Human resources development/training: targeted training in a range of adaptation techniques, including impact assessment, risk management and the integration of these techniques within national development planning and the wider community. **Education/building awareness** Information support to communities through education and awareness programs. **Institutional strengthening** Relevant government ministries, such as national planning, finance and environment and local organisations and community groups involved in vulnerability assessment and adaptation. **Impact on greenhouse gas emissions/sinks (optional)** Not quantified.			

Table 7.4 ***(continued)***

Indonesian National Carbon Accounting System			
Purpose			
Australian support to the Indonesian National Carbon Accounting System aims to increase forest carbon monitoring and accounting capacity in Indonesia. This support is part of Australia's International Forest Carbon Initiative.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Indonesia	Forestry	$2 million	July 2007 – ongoing

Description

As part of the International Forest Carbon Initiative, the Australian Government is assisting Indonesia to design and implement the Indonesian National Carbon Accounting System (INCAS) and the related Forest Resource Information System (FRIS). Both systems will support Indonesia's ability to monitor and curb greenhouse gas emissions from deforestation and forest degradation.

The INCAS is being modelled on Australia's National Carbon Accounting System (NCAS), but is being developed to suit Indonesia's unique circumstances. The Government of Indonesia has completed designs and work plans for the INCAS and FRIS with technical and financial support from the Government of Australia.

To implement the INCAS and FRIS, Australia is supporting Indonesia to complete wall-to-wall land cover change analysis. Landsat data from various sources, as well as assistance to Indonesia to utilise its extensive Landsat archive, have been provided. Computer hardware and software required for processing the data have been supplied and training in scene selection and image processing has been successfully conducted. Future work will focus on completing data procurement, scene selection and image processing.

Australia is also assisting Indonesia to undertake research and analysis to relate land-use change to biomass and carbon stocks, which will enable estimates of greenhouse emissions over time.

To date, technical support has been provided to collect primary and secondary literature on forest biomass and allometric equations from multiple sources. Further data and literature review will be undertaken with a view to determining additional data collection requirements.

Indicate factors which led to project's success

The project is being led by the Government of Indonesia and addresses its specific priorities.

Technology transferred

Expert systems, databases, monitoring and reporting analysis.

Asia-Pacific Partnership on Clean Development and Climate

The **Asia–Pacific Partnership on Clean Development and Climate** brings together Australia, Canada, China, India, Japan, the Republic of South Korea and the United States to address the challenges of climate change, energy security and air pollution in a way that encourages economic development and reduces poverty.

The partnership represents around half of the world's emissions, energy use, GDP and population and engages the key greenhouse gas–emitting countries in the Asia–Pacific. With its focus on the development, deployment and transfer of cleaner, more efficient technologies, the partnership is also unprecedented in the way business, government and researchers have agreed to work together.

In January 2006, the Australian Government announced a funding commitment of $100 million over five years for the partnership. Currently Australia has allocated over $84 million to more than 55 projects. These projects are drawn from across the eight partnership task forces on:

- aluminium
- buildings and appliances
- cement
- cleaner fossil energy
- coal mining
- power generation and transmission
- renewable energy and distributed generation
- steel.

International Renewable Energy Agency

Australia became a member of the **International Renewable Energy Agency** in June 2009. The agency is a treaty-level inter-governmental organisation of more than 130 sovereign member states, and aims to work with member countries and other international organisations to accelerate the development and deployment of renewable energy.

International Energy Agency technology network

Australia is an active participant in the range of technology activities under the **International Energy Agency** (IEA). These include the Implementing Agreements, which are the IEA's framework for coordinating international research and development on energy technologies; the IEA's Committee on Energy Research and Technology; and the energy technology working groups and experts' groups. Reducing emissions from energy production and use is a key policy objective of the IEA's current work, advanced through the *Energy Technology Perspectives* publication and its associated technology roadmaps.

Climate Technology Initiative

Australia is currently a member of the IEA's **Climate Technology Initiative**. Member countries undertake a broad range of cooperative activities in partnership with developing and transition countries and other international bodies to accelerate development and diffusion of climate-friendly and environmentally sound technologies and practices. Australia supports the initiative's role in creating enabling environments, which includes addressing market barriers to private sector investment and deployment of technology. Activities are designed to be consistent with the UNFCCC objectives, in particular the framework for technology cooperation incorporated in the Marrakech Accords and adopted at the Seventh Conference of the Parties to the UNFCCC.

7.5.4 Technology partnerships

The **Methane to Markets Partnership** is an international initiative that focuses on advancing cost-effective, near-term methane recovery and use as a clean energy source. The partnership is designed to promote collaboration between developed and developing country partners—with strong participation from the private sector—to enhance economic growth, improve energy security and reduce greenhouse gas emissions. It aims to promote the adoption of existing technologies focusing on methane emissions from coalmines, landfills, agriculture and the oil and gas sectors.

Australia joined the partnership at its launch in November 2004. A major focus for Australia under the partnership has been to advance collaboration on the recovery and use of coalmine methane with China—the world's leading producer of emissions in this sector. The partnership has also provided opportunities for Australian companies specialising in landfill gas to develop export markets in China.

The Asian Development Bank's **Clean Energy Financing Partnership Facility** was established in April 2007 to promote clean energy investments in Asia and the Pacific. The facility provides financial

resources and technical support to improve energy security in developing countries and promote technologies and practices that reduce greenhouse gas emissions.

Australia joined the facility in September 2007 and has provided $7 million to its Clean Energy Fund and $21.5 million, through the Global Carbon Capture and Storage Institute, to its Carbon Capture and Storage Fund.

Australia is a founding member of the **International Partnership for the Hydrogen Economy**. The partnership, established in 2003, advances the transition to a hydrogen economy and provides a forum for international government cooperation and information sharing in advancing hydrogen and fuel cell technologies. The partnership works to progress policies, develop common technical codes and standards, and educate stakeholders on the benefits and challenges of integrating hydrogen technologies into the marketplace.

Australia is a founding member of the **International Partnership for Geothermal Technology** (IPGT) with the United States and Iceland. The primary focus of IPGT collaborations are technologies applicable to enhanced geothermal systems and supercritical hydrothermal resources.

Australia is providing $1.5 million to the **Renewable Energy and Energy Efficiency Partnership**, an international non-government organisation that aims to increase the use of renewable energy and energy-efficient technologies. Australia's funding supports projects in the Pacific region as part of the seventh Global Funding Round.

The **Carbon Sequestration Leadership Forum** is an international climate change initiative that is focused on cooperation to develop and apply technologies for the separation and capture of carbon dioxide for transport and long-term safe storage. The purposes of the forum are to make these technologies broadly available internationally, and to identify and address wider issues relating to carbon capture and storage. This could include promoting the appropriate technical, political and regulatory environments for the development of these technologies.

7.6 Other initiatives

7.6.1 Financing to support impact of response measures

Measures taken to respond to climate change have the potential to impact all UNFCCC parties. As with other major energy exporters, Australia's exports are susceptible to fluctuations in demand based on a wide range of causes. Australia supports other countries to respond to the impact of response measures through national policies and measures, including diversifying economies, and building economic resilience, to place countries in a much better position to adapt to trends in the global economy.

Australia has in place a number of support programs to assist vulnerable countries to build economic resilience. For instance, Australia is providing $12.5 million for the International Finance Corporation's Pacific Enterprise Development Facility, which is improving the business environment for small and medium-sized enterprises in the Pacific, through targeted programs of technical assistance. The work covers access to finance, tourism, business enabling environments and rural export development.

Australia has also provided more than $3 million to support Pacific island countries in moving to closer economic integration through negotiation of a regional free trade agreement, the Pacific Agreement on Closer Economic Relations, known as PACER Plus. Australia's support focuses on four components: capacity building, policy analysis and research, stakeholder consultation and engagement, and trade facilitation and promotion. Programs include expert training for trade officers and funding for countries to commission independent trade research.

In total, Australia provided around $391 million in 2008–09 in Aid for Trade-related activities, which are intended to support high and sustained trade-led growth, and which will, among other things, support developing countries build the economic resilience necessary to adjust to the impacts of climate change response measures.

In addition, Australia recently pledged at least $25 million over four years from 2009–10 for initiatives in clean and affordable energy in the Pacific region. An important focus of this funding will be to reduce dependence on fuel imports and therefore vulnerability to a carbon price.

7.6.2 Australian Centre for International Agricultural Research

Through the **Australian Centre for International Agricultural Research** (ACIAR), the Australian aid program supports collaborative research and development projects between Australian and developing country organisations. This helps solve major agricultural and resource problems and strengthen local research capacity. ACIAR-supported research relevant to climate change includes:

- in forestry, technical and social research to support the development of community-based planted forests in Pacific island countries, including Papua New Guinea, and in Indonesia, and research to underpin improved governance, policy and institutional arrangements to reduce emissions from deforestation and degradation (REDD) in Indonesia
- following on from pilot work in 2008, ACIAR commenced an R&D program in 2009 on adaptation to climate change in rain-fed agricultural regions in Lao PDR, Cambodia, Bangladesh and parts of India
- support of irrigated rice-based systems in the Mekong Delta of Vietnam, which will support the development of drought- and submergence-tolerant rice germplasma, targeted at improving farm systems and fertiliser management use and reduced greenhouse gas emissions.

References

GEF Evaluation Office 2009, *Fourth Overall Performance Study of the GEF: Progress Toward Impact*, Global Environment Facility.

UNFCCC 2008, *Mechanisms to Manage Financial Risks from Direct Impacts of Climate Change in Developing Countries*, UNFCCC.

CHAPTER 8

Research and systematic observation

KEY DEVELOPMENTS

The National Framework for Climate Change Science was adopted by the Australian Government in May 2009. The framework brings together Australia's climate change expertise to deliver the essential science needed for an effective national response to climate change.

Following the release of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology released *Climate Change in Australia: Technical report 2007*. The report provides an up-to-date assessment of observed climate change in Australia, the likely causes, and projections of future changes to Australia's climate.

As part of the 2009 Super Science Initiative, the Australian Government is investing $387.7 million in research infrastructure to improve Australia's ability to respond to climate change and to better understand and protect Australia's 13 million sq km of marine territory. This builds on the investment under the National Collaborative Research Infrastructure Strategy program (2005–11) in research infrastructure, including in areas that support climate change response.

The Centre for Australian Weather and Climate Research has developed an internationally competitive climate modelling system, the Australian Community Climate and Earth-System Simulator (ACCESS). ACCESS is now operational for weather prediction and, by 2011, it will provide long-term global and regional climate projections and be a key platform for Australia's contributions to the IPCC Fifth Assessment Report.

The Antarctic Climate and Ecosystems Cooperative Research Centre has delivered new estimates of ocean warming and sea-level rise showing that, since 1961, the trend in thermal expansion has been 50% larger than previous estimates. There is now good agreement between the observed variability in thermal expansion and the ocean warming inferred from global climate models.

Australian scientists continue to play an active role in research on climate and climate change. This commitment to research means that Australia has the most comprehensive research and monitoring activities related to climate change in the southern hemisphere. Australia supports this activity through climate change science and systematic observation aimed at advancing our understanding of global and regional climate change, and its possible effects on Australia's natural and managed systems. This research is broadly based, covering climate processes, modelling and the impacts of climate and climate change on various sectors of society. It contributes significantly to the assessments of the IPCC, including the 2007 Fourth Assessment Report and the upcoming Fifth Assessment.

8.1 National Framework for Climate Change Science

In recent decades Australia has made a strong contribution to global climate change knowledge, particularly on key processes such as the drivers of sea-level rise in the southern hemisphere. The Australian climate change science community is facing increased demand from decision makers and the public for more detailed information on climate change.

To meet this demand, the Australian Government recognised the need for a nationally coordinated climate change science effort. The National Framework for Climate Change Science was adopted by the government in May 2009. The framework will bring together Australia's climate change expertise to deliver the essential science required for an effective national response to climate change. The framework was developed in consultation with the research community and stakeholders across government.

The framework focuses on the fundamental climate system science. This science helps us understand the systems, mechanisms and feedbacks that determine changes over time to the earth's climate, including changes due to human activity. The framework comprises four main elements:

- identifying the challenges, or key areas, where the science must deliver information to inform decisions over the next decade. This includes:
  - tracking, understanding and predicting the future changes in greenhouse gas levels
  - providing better climate information to help manage Australia's demand for urban water, and water for agricultural use, environmental flows and hydroelectric energy production
  - providing information on the impact of climate change on the ocean and coastal regions
  - providing information and knowledge needed for national adaptation initiatives to minimise societal disruption and costs associated with changes in extremes of weather and climate
  - improving our ability to predict atmospheric behaviour across short, medium and long timescales
- developing the capabilities Australia needs to meet these challenges, which include:
  - climate observations
  - climate process studies
  - observations-modelling integration
  - predicting future climate change
  - linking climate with social and economic systems.
- addressing the need for people and infrastructure to support those capabilities and meet the challenges
- implementing the framework, which will require national coordination and adequate investment.

The development and implementation of the framework is overseen by a high-level coordination group consisting of major funding bodies, key research organisations and senior scientists. It is chaired by the Chief Scientist for Australia, who will report annually to the Minister for Climate Change and Water and the Minister for Innovation, Industry, Science and Research on progress in implementing the framework.

The framework will provide centralised coordination of Australia's entire climate change science expertise. This will include creation of multi-institutional teams—for example, universities working with other research organisations such as the Centre for Australian Weather and Climate Research, the Australian Antarctic Division and the Antarctic Climate and Ecosystems Cooperative Research Centre. The framework's centralised approach will keep Australia at the forefront of global efforts to develop the science needed for mitigating and adapting to climate change.

CLIMATE CHANGE IN AUSTRALIA: TECHNICAL REPORT 2007

Australia has published projections of regional climate change following the release of the major IPCC reports, providing regional detail consistent with the IPCC's global projections. After the release of the IPCC Fourth Assessment Report, in 2007 CSIRO and the Bureau of Meteorology published a technical report, *Climate Change in Australia*. The report provides an up-to-date assessment of observed climate change in Australia, its likely causes, and projections of future changes to Australia's climate. The report also summarises the most recent methodologies for applying the projections in an impact assessment.

The report reflects the advances that have been made since the CSIRO's 2001 report on climate change projections, including projections for a larger set of climate variables and the use of a greater range of climate models to produce probabilistic projections for the first time. The report also places a greater emphasis on projections from models that are better able to simulate the observed Australian climate.

The major findings of the report included:

- Increased Australian land temperatures since the middle of the 20th century are likely to be primarily due to increases in greenhouse gas concentrations from human activities.
- Australian average temperatures have increased 0.9°C since 1950, with significant regional variations. The frequency of hot days and nights has increased and the frequency of cold days and nights has declined.
- The best estimate of annual warming over Australia by 2030 relative to 1990 is about 1°C for mid-range emissions,[1] with warming of around 0.7–0.9°C in coastal areas and 1–1.2°C inland. By 2070, annual warming is around 1.8°C for the low-emissions case, but around 3.4°C for the high-emissions case.
- Substantial warming has occurred in the three oceans surrounding Australia and increases in ocean acidity are expected in the Australian region, with the largest increases in the high to mid latitudes.
- For 2030, best estimates of annual rainfall indicate little change in the far north and a decrease of 2% to 5% elsewhere. There is also likely to be an increase in extreme weather events including drought, fire weather, tropical cyclones and storm surges.

The report has been a central source of information on possible future climate change effects on Australia. Further modelling on regional scales has been done since the report's publication, suggesting a reduction of frost occurrences across the Murray–Darling Basin, and a further reduction of early winter rainfall in south-west Western Australia. The Australian Climate Change Science Program (see page 153) has supported initiatives to make climate change projections more accessible to users. CSIRO has updated its OzClim climate scenario generator with a new interface and expanded online access to projections data. Work is also under way on a user-friendly interface for accessing projections from the Bureau of Meteorology's statistical downscaling model.

1 For a full description of the scenarios used in the modelling please refer to page 36 of the report.

8.2 Research capacity

Australia's capacity to address the challenges posed by climate change has improved considerably since Australia's Fourth National Communication. This section provides an overview of key Australian research organisations and funding initiatives.

8.2.1 Key research organisations

The **Centre for Australian Weather and Climate Research** is a partnership between CSIRO and the Bureau of Meteorology. It was established in 2007 to ensure that Australia remains a world leader in climate and weather research so that it can meet the weather and climatic challenges that continue to confront the nation. The centre delivers a number of advantages, including access to a wide range of research skills, efficient use of resources, and increased potential to develop research relationships with government, industry and other research providers.

The **Antarctic Climate and Ecosystems Cooperative Research Centre** plays a central role in Australia's national effort to understand Antarctic and Southern Ocean processes and their effects on global and regional climate. In August 2009, the Australian Government announced an additional $20.1 million in funding to continue the centre until 30 June 2014.

The **Australian Institute of Marine Science** supports and contributes to several observational networks, including the Great Barrier Reef Ocean Observing System node of the Integrated Marine Observing System. Its goal is to better understand and monitor variability and changes in the tropical marine environment. The institute also engages in collaborative initiatives with institutions such as the Western Australian Marine Science Institution, which researches climate processes, predictability and impacts of a warming Indian Ocean.

The **Australian Nuclear Science and Technology Organisation**'s Isotopes in Climate Change and Atmospheric Systems Project uses nuclear-based technologies and analytical capabilities to study how the earth's climate systems have changed, and how the land surface interacts with the atmosphere.

Universities across Australia are active in various aspects of climate change research, ranging from ocean and terrestrial observational studies to emissions reduction and adaptation responses. This includes a number of climate change–focused centres, such as the ANU Climate Change Institute at the Australian National University and the Climate Change Research Centre at the University of New South Wales.

As part of the 2009 Super Science Initiative (see 8.2.2 and Annex IV), the Australian Government announced the creation of a new scheme, the **Australian Research Council Super Science Fellowships**, which aims to attract and retain outstanding early-career researchers in three key areas, one of which is marine and climate research.

The **Australian Research Council Research Network for Earth System Science** received funding of $1.95 million over the five years to 2009 for the purpose of linking researchers in universities and other institutions investigating the effects of climate change and variability on human, biological and physical systems.

The **Queensland Climate Change Centre of Excellence** was launched in March 2007. The centre's aim is to ensure that Queensland Government policy, programs and initiatives are informed by the best available climate science. See 8.3 and 8.4.1 for more information about the centre's activities.

8.2.2 Major funding initiatives

The **Australian Climate Change Science Program** (ACCSP) funds research to improve the understanding of the causes, nature, timing and consequences of climate change for Australia and our region. The program is administered by the Department of Climate Change in partnership with CSIRO and the Bureau of Meteorology. Research projects are being undertaken by the Antarctic Climate and Ecosystems Cooperative Research Centre, Monash University, the Australian National University, the University of New South Wales and Wollongong University.

ACCSP funding is helping to develop and maintain a state-of-the-art modelling capacity, known as ACCESS (the Australian Community Climate and Earth-System Simulator) (see 8.4.2). ACCSP funding also enables the Australian Academy of Science to provide links with key international climate change science programs. See 8.3 for more information.

In 2009 the ACCSP was granted funding of $31.2 million over four years. This funding is matched by contributions from CSIRO and the Bureau of Meteorology. See 8.3 for more information about this program.

As part of the $1.1 billion **Super Science Initiative**, in 2009 the Australian Government is investing $387.7 million in research infrastructure over four

years to 2012–13 to improve Australia's ability to respond to climate change and to better protect and understand Australia's 13 million sq km of marine territory. This comprises:

- $52 million to extend and enhance Australia's Integrated Marine Observing System (IMOS). This investment builds on the $50 million investment in IMOS through the National Collaborative Research Infrastructure Strategy program. More details are provided in 8.5.1.
- $120 million to construct a new marine research vessel capable of exploring Australia's vast ocean territory, and operate the existing vessel until the replacement is available. The vessel will be operated by CSIRO and used by marine researchers across Australia. The Government will also provide additional funding of $29.6 million over four years from the budget for:
  - RV *Southern Surveyor* operating and maintenance costs to 2011–12
  - operating costs for the new vessel in 2012–13
  - project management costs that will be incurred by CSIRO during the construction project.

  This funding will ensure that Australian scientists continue to have access to the research vessel capability required to work at sea in addressing national research priorities, principally
  (1) responding to climate change and variability
  (2) developing deep earth resources and
  (3) sustainable use of Australia's biodiversity.
- $55 million to construct new tropical marine research facilities at the Australian Institute of Marine Science in Townsville and Darwin.
- $35 million to extend and enhance the Terrestrial Ecosystem Research Network. This investment builds on the $20 million investment through the National Collaborative Research Infrastructure Strategy, which is still under development. The network, led by the University of Queensland, is envisaged as a set of dedicated observation sites with standardised measurement methodologies, equipment and data and information services that collectively will contribute to meeting the needs of terrestrial ecosystem research and natural resource management in Australia for observing and monitoring data related to terrestrial ecosystems and potentially coastal ecosystems.
- $50 million to provide new high-performance computing facilities for use by the Bureau of Meteorology, CSIRO, the Australian National University and leading researchers from around Australia to address climate change, earth systems science and national water management issues. The objectives of the new computing infrastructure will be to:
  - provide an internationally significant high-performance computing capability and associated data support to prioritised research endeavours
  - develop and operate a resource allocation system that gives priority research on-demand access to allocated resources
  - support meritorious research in all fields through the provision of 'capability' quality computational services
  - provide a data centre facility suitable for continuous system upgrade through to 2020.

The **Indian Ocean Climate Initiative** is a research partnership between the Western Australian Government, CSIRO and the Bureau of Meteorology. The partnership is investigating the causes of the significant rainfall reductions experienced since the 1970s in Western Australia and developing projections of the future climate. See 8.4.2 for more information about this initiative.

The Bureau of Meteorology and CSIRO are contributing to the **South-Eastern Australian Climate Initiative**, which is investigating the causes and effects of climate change and climate variability across south-eastern Australia, including the Murray–Darling Basin. See 8.4.1 for more information about this initiative.

8.3 International cooperation

Australians participate in many international scientific committees and Australia's climate change scientists make valuable contributions to global climate change research. For example, Australia made a strong contribution to the IPCC Fourth Assessment Report, for which dozens of Australian researchers acted as authors and reviewers. In addition, a senior scientist in CSIRO chairs the Joint Scientific Committee of the Geneva-based World Climate Research Programme.

Australia is also a member of other international climate change research and information exchange programs and organisations. For example, Australia is in the process of establishing an Asia–Pacific Climate Change Exchange to promote collaboration between Australian businesses and researchers and their regional partners. Australia participates in the

Asia–Pacific Network for Global Change Research, an intergovernmental network that promotes global change research and links between science and policy-making in the Asia–Pacific region.

The **Australian Climate Change Science Program** contributes funding for Australia's bilateral and multilateral relationships with other countries. For example, the program facilitates Australian participation in two significant international programs through the Australian Academy of Science: the International Geosphere–Biosphere Program and the World Climate Research Program. The program also supports an Australian-based international project office of the Global Carbon Project of the International Geosphere–Biosphere Program.

In addition, a key aim of the ACCESS model development (see 8.4.2) is to facilitate international collaboration to more effectively build knowledge and understanding of the global climate system. The ACCESS team collaborates with the UK Met Office, along with the Korean Meteorological Administration and the National Institute of Water and Atmospheric Research of New Zealand.

Australian researchers also contribute to international climate research through their participation in the activities of the World Climate Impacts and Response Strategies Program and continue to play prominent roles on the Scientific Committee on Antarctic Research and its subcommittees.

The **Queensland Climate Change Centre of Excellence** works with Australian and international research agencies, industry and all levels of government to addresses climate change issues of relevance to Queensland. This includes partnering with overseas institutions, such as the Walker Institute at the University of Reading in the United Kingdom and the Hadley Centre of the UK Met Office, and working through the Queensland–China Climate Change Fellowship Program.

The **Pacific Climate Change Science Program** is a $20 million program that aims to help Australia's neighbouring island countries gain a better understanding of how climate change will affect the region. Initiated in 2008, the program, working with partner countries, will:

- track recent and current climate trends
- investigate regional climate drivers
- provide regional climate projections
- improve understanding of ocean processes including acidification and sea level rise.

The program is managed by the Department of Climate Change in collaboration with the Australian Agency for International Development (AusAID). It is delivered by the Bureau of Meteorology and CSIRO through their research partnership in the Centre for Australian Weather and Climate Research. The program forms one component of Australia's International Climate Change Adaptation Initiative (see 7.3.1).

The Bureau of Meteorology implements and manages the AusAID-funded **Pacific Islands – Climate Prediction Project**, which aims to increase the understanding of the links between climate variability (including intraseasonal, seasonal and interannual timescales), regional climate change and local-scale impacts of climate change. The project's primary goals are to strengthen the capacity of Pacific island countries to make climate predictions and to provide other climate-related information. See 8.5.3 for more information about this project.

8.4 Research focus

Australian research into climate change focuses on four main areas:

- process studies—examining the mechanisms that drive climate change and its effects
- climate models—using simulations of future climate scenarios to help Australia better understand climate (including climate variability and change), attribute the causes of climate changes, and project future climate, at both global and regional scales
- emissions reduction technologies—developing technologies that assist in reducing the amount of greenhouse gases emitted into the atmosphere
- systematic observations—collecting data that can be used in explaining how different elements of the climate system operate.

8.4.1 Process studies—understanding key drivers of climate change

Ocean processes

ACCSP-funded research focuses on the oceans surrounding Australia—the Southern, Indian and South Pacific. Researchers have identified long-term temperature changes in the Indian Ocean, and deep-ocean warming in the Pacific Ocean.

An important source of ocean information is the Argo project, which collects temperature and salinity observations from more than 3000 free-drifting ocean-profiling floats and makes it publicly available within hours of collection. Researchers are investigating the thermohaline circulation, the 'conveyor belt' that transports heat, nutrients and oxygen around the world's oceans. A major component of this circulation is Antarctic bottom water. Scientists have documented rapid and widespread freshening of Antarctic bottom water in the Indian and Pacific Oceans, an indicator that climate change is already having an effect on global oceanic circulation.

Mesoscale (approximately 50 km in diameter) eddies in the ocean have a major impact on the transport of water and heat. For accurate modelling of the oceans for climate studies, these eddies must be properly represented. Researchers have applied temporal-residual-mean theory to enable the three-dimensional behaviour of ocean eddies to be successfully included in ocean models. The work has led, among other improvements, to a five-fold improvement in the models' capacity to simulate the bottom three kilometres of the ocean. The application of this work in southern hemispheric modelling is particularly important given the vital role that the Southern Ocean plays in the global thermohaline circulation.

Oceans also store and transport carbon dioxide. As the Southern Ocean is one of the earth's most significant carbon sinks, understanding its capacity for carbon storage and uptake is critical. ACCSP research has shown that the Tasman Sea is a strong carbon sink year round, with the greatest carbon uptake in spring.

Ocean acidification

Researchers at the University of New South Wales and CSIRO have found that an intense wintertime minimum in carbonate ions south of the Antarctic Polar Front, when combined with anthropogenic CO_2 uptake, is likely to induce aragonite undersaturation when atmospheric CO_2 levels reach 450 ppm. This means the 'tipping point' of ocean acidification, when carbonate levels are too low for some plankton to build and maintain shells, may be reached much earlier than previously predicted.

Antarctic and Southern Ocean research

Since Australia's Fourth National Communication, the Antarctic Climate and Ecosystems Cooperative Research Centre has made a number of significant strides in its research, including:

- delivering new estimates of ocean warming and sea-level rise showing that, since 1961, the trend in thermal expansion has been 50% larger than previous estimates. There is now good agreement between the observed variability in thermal expansion and the ocean warming inferred from global climate models
- discovering the first field evidence of ocean acidification causing ecological impacts on Southern Ocean organisms that use carbonate ions to build their shells. The shell weights of these organisms were compared across samples from the geological past to those just prior to the industrial revolution and those from modern times. The study found a 38% reduction in shell weights since 1750, corresponding with increased atmospheric levels of carbon dioxide and ocean acidification
- demonstrating that the Southern Ocean plays a particularly important role in buffering the accumulation of carbon in the atmosphere through its uptake of carbon dioxide. The study also led to improved understanding of the key limitations on that buffering capacity (for example, dissolved iron)
- providing the first circumpolar snapshot of the physical, biogeochemical and ecological environments of the Southern Ocean region through coordinated multinational research cruises. The study provided evidence that Antarctic bottom water in the Australian Antarctic Basin continues to freshen at a rapid rate and that this has implications for global thermohaline circulation.

Indian Ocean climatic influences

The see-sawing nature of sea-surface temperatures in the east and western Indian Ocean is known as the Indian Ocean Dipole. When the dipole is in a positive phase, sea water off the Sumatra–Java coast, north-west of Australia, tends to be cooler than normal, leading to a reduction in the rain-bearing systems that normally extend to Victoria during spring.

Over the past 30 years, consistent with IPCC assessments, the frequency of positive occurrences of the Indian Ocean Dipole has risen. The weather conditions that led to Victoria's past two major bushfires may be linked to the positive phases of the dipole.

Global and regional sea-level rise

The rate of ocean thermal expansion since 1970 is greater than previously estimated. CSIRO researchers and their colleagues have identified a significant acceleration in the rate of sea-level rise from 1870 to 2004. Australia's investigations into rates of sea-level rise are ongoing. See 6.1.2 and 6.2.1 for more information on the vulnerability of Australia's coastline to sea-level rise.

Marine ecosystems

The first-ever Australian benchmark of climate change impacts on marine ecosystems and options for adaptation was released on 27 November 2009. The *Marine Climate Change Impacts and Adaptation Report Card for Australia*, and an accompanying website, is a guide for scientists, government and the community to review observed and projected impacts of climate change on marine ecosystems. The project, funded by the Australian Climate Change Science Program, the National Climate Change Adaptation Research Facility (NCCARF) and the CSIRO Climate Adaptation Flagship, is an early outcome of a broader national response to climate change being conducted through the NCCARF (see 6.3.1).

The report card highlights observations of marine climate change over the past decade, and projects forward to 2030 and 2100 with assessments of likely status and confidence ratings. Key concerns include the waters around Australia becoming warmer and more acidic; increases in strengths of major warm-water currents such as the East Australian Current; changes in the productivity of marine ecosystems; and shifts in the distribution and abundance of species. The report card identifies where change is already occurring, likely trends, and confidence levels in those trends depending on the current state of knowledge. The research team comprises 70 marine scientists from universities, state and territory environmental agencies, the Australian Institute of Marine Science, the Bureau of Meteorology and CSIRO.

Aerosols and clouds

Researchers are working to understand the behaviour of aerosols and clouds, and are incorporating their findings into improved climate models. Elevated particle emissions resulting from increased economic activity in Asia may have increased Australia's tropical rainfall, because the 'haze' cools the Asian continent and nearby oceans, altering the delicate balance of temperature and winds between Asia and Australia. There has also been successful international collaboration on field experiments aimed at increasing our understanding of key atmospheric processes including clouds, such as the Tropical Warm Pool International Cloud Experiment.

Terrestrial carbon cycle

The ACCSP supports research to provide a more thorough understanding of carbon sinks and sources in the Australian biosphere, and how they might respond in a changing climate. For example, research suggests that rising carbon dioxide levels are likely to favour woody plants at the expense of grass production in Australia's savannas. Water and nutrient availability will affect plant growth.

Data from a measurement tower in Tumbarumba, New South Wales have led to the first estimate of a carbon budget for an uplands forest. This research has supported the development of models for carbon transport in forests and forest growth, and production of weekly land surface evaporation estimates for Australia. Contributions to evaporation estimates come from seven sites.

Vegetation and fire research

Climate change will affect fire regimes in Australia because of changes in temperature, rainfall, humidity and wind—the fire weather components. Climate change will also have complex effects on fuels. On the one hand, elevated levels of carbon dioxide may enhance vegetation production and thereby increase fuel loads. On the other hand, drought may decrease long-term vegetation production (thereby reducing fuel loads) and fuel moisture (thereby increasing potential rates of fire spread). The outcome of these processes on fuels, and hence fire regimes, is highly uncertain, and requires further research.

Climate change projections are for warming and drying over much of Australia, and there is thus an increased risk of severe fire weather, especially in south-eastern Australia. Modelling suggests an increase of 5% to 65% in the incidence of extreme fire weather days by 2020 in this region.

Cloud-seeding research

The Queensland Climate Change Centre of Excellence has been involved in one of the largest cloud-seeding research programs in the southern hemisphere to determine scientifically whether cloud seeding has the potential to increase rainfall in south-east Queensland. While early analysis of the first season's trials indicate an increase in cloud droplet size and rain cell duration (the length of time a downpour lasts), further analysis

and research are required to determine if south-east Queensland conditions will support an operational cloud-seeding program.

Rainfall patterns

Detection and attribution studies have shown that both human activities and natural variability have contributed to the rainfall decline experienced since the 1970s in south-west Western Australia. Around half of this decline can be attributed to increases in greenhouse gases. Local land clearing may have also been a factor. The wet season rainfall increase in most northern parts of north-west Australia has been tentatively linked to increasing Asian aerosols. The extent of the Australian monsoon has also changed, strengthening over parts of north-west Australia.

Researchers have identified a clear north–south rainfall divide on either side of a naturally occurring band of high pressure known as the subtropical ridge. The intensity of the subtropical ridge has been increasing since the 1970s, accompanied by significant rainfall decline in the Murray–Darling Basin. Reductions in rainfall south of the ridge occur in late autumn to winter, and to the north in summer to autumn. It is highly likely that climate change is intensifying the ridge, thereby reducing rainfall and runoff. The **South-Eastern Australian Climate Initiative** is providing a clearer picture of the way in which the Indian and Southern oceans influence the climate of south-east Australia, and of the factors that influence change and alter rainfall patterns and stream and river inflows.

8.4.2 Climate modelling

An Australian climate modelling system

Modelling of climate change has become increasingly sophisticated. In an effort to more realistically capture actual earth system processes and feedbacks, earth-system models now include the atmosphere, land surface, ocean and sea ice, aerosols, the carbon cycle and atmospheric chemistry. The Centre for Australian Weather and Climate Research is developing the Australian Community Climate and Earth-System Simulator (ACCESS), which will deliver a new generation of climate models to improve weather and climate research in Australia. The centre has negotiated a collaboration agreement with the Hadley Centre at the UK Met Office to adopt its unified model, atmospheric chemistry module and data assimilation scheme as the core of ACCESS. ACCESS is now operational for weather prediction; by 2011 it will provide long-term global and regional climate projections and be a key platform for Australia's contributions to the IPCC Fifth Assessment.

Australian researchers will focus on key aspects of identifying, understanding and modelling climate and weather drivers in the southern hemisphere—such as the prediction of the El Niño – Southern Oscillation, the Indian Ocean Dipole and simulation of the Southern Ocean—to feed into ACCESS and the UK Met Office models. ACCESS will provide a unified simulation platform for all timescales (from numerical weather prediction to seasonal prediction and longer-term climate projections, such as decadal projections) that can be applied at global, regional and local spatial scales. Seamless prediction is acknowledged by the global research community to be the state-of-the-art approach needed to deliver high-quality weather and climate simulations.

Climate change, climate variability and extreme events

The effects of climate change are often felt through changes in the frequency and intensity of extreme climatic events. Seemingly modest increases in long-term average temperatures, for example, can lead to an increased likelihood of experiencing many more very hot days. Historical records no longer provide an accurate guide to the future strength and frequency of extreme events.

The ACCSP is supporting research into extreme rainfall and wind events, tropical cyclones, hail and severe storms, storm surges and sea-level rise, drought, and fire risk. In the future, Australia is likely to experience fewer tropical cyclones, although their intensity will increase as temperatures rise. Researchers project that the frequency of the most extreme storms will rise by 60% by 2030 and by 140% by 2070.

There are likely to be more long-lived east Australian tropical cyclones and fewer around north-western Australia. Projections of changes for the end of the century suggest a dramatic increase in hail risk along the south-eastern coastline. The large-hail risk for this region is projected to almost double, increasing by between four and six days a year.

Regional climate change projections

The **Australian Climate Change Science Program** supports research into improving Australia's capacity to generate regional projections of climate change across a range of timescales.

Climate change simulations produced under the **Indian Ocean Climate Initiative** reveal that even with the most optimistic greenhouse gas emissions scenarios, south-west Western Australia is projected to be drier and warmer later this century, with potentially much less water available for storage or for use by agriculture, ecosystems and industry. The latest, third stage of the initiative focuses especially on the north-west of the state.

In 2008, the Queensland Government published *Climate Change in Queensland: What the science is telling us*, which summarises information from key reports including the IPCC Fourth Assessment Report and *Climate Change in Australia: Technical report 2007*. Additional climate change projections for 13 Queensland regions were delivered in August 2009.

The Tasmanian Government has invested $900 000 over three years in the **Climate Futures for Tasmania Project**, which is being undertaken by the Antarctic Climate and Ecosystems Cooperative Research Centre. The project will model climate projections at a local scale (based on global IPCC climate models) to provide regionally relevant information.

8.4.3 Emissions reduction technologies

The Australian Government has allocated $400 million from the Education Investment Fund for research infrastructure related to the **Clean Energy Initiative**. The initiative supports research, development and demonstration of low-emissions technologies, including industrial-scale carbon capture and storage and solar energy. The selection of projects will be completed in the first half of 2010, following a competitive process commencing in the second half of 2009.

The Australian Government launched the **Australian Solar Institute** in 2009, with $100 million allocated to it for the period 2008–12 (see also page 60). The institute is designed to advance Australia's research and development capabilities in solar energy technology. Its key objectives are to:

- advance and accelerate innovation in solar thermal and solar photovoltaic technologies in Australia
- drive research that will have a major impact on the efficiency and cost effectiveness of solar technologies
- increase the competitiveness of solar technologies
- retain local and attract international expertise in solar energy research to Australia
- establish Australia as a key player in the development of solar energy technologies in the Asia–Pacific region.

In 2007 the Australian Government committed $10 million over four years to Geoscience Australia to undertake a greenhouse gas geological storage program. This program, the **National Greenhouse Gas Storage Advice**, is aimed at understanding the potential for geological storage of greenhouse gases in Australia and the delivery of sound technical advice to government regarding the geological storage of greenhouse gases.

This program includes:

- geological studies of sedimentary basins to determine the local, regional and national prospects for storage of greenhouse gases in Australia
- monitoring and groundwater studies to track and understand the behaviour of carbon dioxide in the subsurface
- provision of technical advice into the development of Commonwealth legislation and regulations for storage of greenhouse gases in Australia's offshore sedimentary basins, including the selection of offshore exploration acreage for commercial storage of greenhouse gases
- participation in national activities such as the Carbon Storage Taskforce, and international engagement in forums such as the Carbon Sequestration Leadership Forum and the Asia–Pacific Partnership on Clean Development and Climate
- advice to policy developers, policy makers, state, non-government and commercial bodies and the general public about geological storage.

Since 1998, as the Australian Petroleum CRC, and from 2003 as the **Cooperative Research Centre for Greenhouse Gas Technologies**, CO2CRC has been conducting comprehensive research into carbon dioxide capture and geological storage, with significant support from governments, industry and research institutions. With approximately 200 researchers undertaking leading-edge research and demonstration, from nano to macro scale and across the full carbon capture and storage chain, it is one of the most comprehensive research organisations in the field.

The CO2CRC Otway Project is the world's largest dedicated research facility to demonstrate the deep geological storage of carbon dioxide. Since 2008, the project has:

- safely injected, stored and comprehensively monitored more than 65 000 tonnes of carbon dioxide under Australian conditions
- undertaken extensive research into the monitoring and verification required for a carbon dioxide storage project
- significantly contributed to the Australian guidelines and legislation on carbon capture and storage
- worked with the local community to assure them of the safety of the project and achieve their support.

In 2009, CO2CRC launched two world-class carbon dioxide capture research facilities at power stations to enable research into innovative capture techniques to establish the most effective and economical processes for different applications.

CO2CRC capture researchers have:

- successfully trialled innovative new solvents, adsorbents and membranes with the potential to greatly improve efficiency
- undertaken economic and process integration studies with the aim of significantly reducing the costs of carbon capture and storage
- lodged several patents for carbon capture and storage technologies.

CO2CRC is also a trusted source of information on carbon capture and storage, a provider of educational material and training and a major contributor to programs of international organisations.

The **South Australian Centre of Excellence for Geothermal Research** focuses on supporting the development of the geothermal energy industry in Australia. It will conduct research into enhanced geothermal systems and into power systems that provide economically and environmentally viable delivery of geothermal energy.

Western Australia's **Low Emissions Energy Development Fund** supports technological development designed to reduce greenhouse gas emissions from the energy sector. Some of the achievements under the fund include the design of an oil mallee tree harvester as part of a bioenergy system and the expected construction of a wave energy demonstration plant by 2012.

The **Narrogin Integrated Wood Processing Demonstration Plant** in Western Australia is designed for the production of electricity, eucalyptus oil and activated carbon from oil mallee feedstock. Some of the plant's key achievements are:

- successful construction and operation of a 1 MW pilot integrated wood processing plant with the overall process technology able to be scaled up from batch to continuous production
- renewable electricity able to be produced for sale
- achieving a quality of activated carbon and eucalyptus oil co-products suitable for international markets.

The **Western Australian Geothermal Centre of Excellence** is conducting multidisciplinary research to exploit and use low-temperature geothermal energy from the Perth Basin.

The Queensland Government is investing $3.5 million in **Carbon Accumulation through Ecosystem Recovery**, a new web-based information system to assist landholders to establish reforestation projects for the domestic carbon market using native vegetation types. Reforestation projects have the potential to significantly reduce Australia's greenhouse gas emissions at relatively low cost, but they need to be informed by the latest information on the carbon potential of vegetation options.

The Queensland Government has invested $15 million in the **Queensland Geothermal Energy Centre of Excellence** at the University of Queensland. The centre has a research and development focus on energy derived from subterranean hot rocks.

The New South Wales Government has allocated $16.5 million to the **Clean Coal Fund** for 2009–10, to fund research, demonstration and commercialisation of clean coal technologies to increase public awareness of the importance of reducing greenhouse gas emissions through clean coal technologies.

The **New South Wales Renewable Energy Development Program** provides $40 million over five years to support projects that are expected to lead to large-scale greenhouse gas emission savings in New South Wales by demonstrating renewable energy technologies and supporting the early commercialisation of renewable energy technologies.

Biodiverse Carbon Planting Project—Tasmania: the Tasmanian Government has provided $530 000 in funding, in partnership with the University of Tasmania and Greening Australia, to research

the sequestration potential of biodiverse carbon plantings across steep environmental gradients in the Derwent Valley.

Other programs that relate to emission reductions technologies are described in Chapter 4, including the Carbon Capture and Storage Flagship program and the Green Car Innovation Fund.

8.5 Systematic observation

8.5.1 Coordination

Global Climate Observing System (GCOS)

Australia's GCOS-related activity is coordinated through the Bureau of Meteorology, although there are other organisations that collect small pieces of data. Significant planning is undertaken to ensure appropriate correlation between Australian and international needs and the data that are collected. For example, in October 2007 Australia hosted an international workshop entitled 'Future climate change research and observations: GCOS, WCRP and IGBP learning from the IPCC AR4'.

Other climate observing programs

Australia has made significant progress in improving the coordination of its research programs, particularly in the oceanic domain. Programs such as the Integrated Marine Observing System (www.imos.org.au), BLUElink (www.marine.csiro.au/bluelink) and the Australian Ocean Data Centre (www.aodc.gov.au) are providing coordination across different sectors, agencies and interest groups.

Integrated Marine Observing System

The Integrated Marine Observing System (IMOS), which was established in 2007 under the Australian Government's $542 million National Collaborative Research Infrastructure Strategy program, is a nationwide collaborative initiative with a distributed observing network and information services designed to observe the oceans around Australia, including both the coastal (continental shelf) and open oceans. The system supports operational forecasting through the Bureau of Meteorology and the BLUElink initiative. Sustained ocean observing under the initiative will inform studies of the role of the ocean in the global climate system, and the impact of major boundary currents on continental shelf environments, ecosystems and biodiversity. IMOS also partly funds Argo Australia, which is described below. See 8.5.6 and Annex IV for more information about IMOS's role in ocean observations.

The University of Tasmania hosts IMOS and oversees the operation of its five nodes and 11 facilities, in conjunction with a number of key partners including CSIRO, the Australian Institute of Marine Science, the Bureau of Meteorology and the Australian Nuclear Science and Technology Organisation, as well as universities and state governments. These nodes and facilities use state-of-the-art marine observing technology to collect data from across Australian waters and marine shelves. Twenty-seven institutions are involved in the facility with vastly different sectoral interests but the coordination provided under IMOS ensures the collection of data that meets all of their needs.

The initial $50 million invested in IMOS was supplemented by significant monetary and in-kind co-contributions from several participants. In May 2009, an additional $52 million from the Marine and Climate Super Science Initiative was allocated to enhance IMOS and extend coverage into northern Australian and Southern Ocean waters. The planning process for these funds is now under way. Free and open access to IMOS data streams is provided through the IMOS website.

Argo Australia is part of IMOS and is also supported by the Australian Department of Climate Change, CSIRO's Wealth from Oceans Flagship, the Bureau of Meteorology, the Royal Australian Navy and the Antarctic Climate and Ecosystems Cooperative Research Centre. Australia's contribution to the global Argo program is significant, as the third largest contributor to the program behind the United States and Japan. Argo is also a key data source for BLUElink, the system that provides the first operational ocean forecasts for the Australian region.

Australian Ocean Data Centre

The Australian Ocean Data Centre receives funding from IMOS to develop the eMarine Information Infrastructure, which will provide a single integrated framework for data and information management, discovery and access for the IMOS nodes.

BLUElink

The Australian Government, through the Commonwealth Bureau of Meteorology, Royal Australian Navy and CSIRO, initiated BLUElink, a $15 million project to deliver ocean forecasts for the Australian region. The forecasts will provide

information on the coastal and ocean currents and eddies, surface and subsurface ocean properties that have an impact on, and are linked to, maritime and commercial operations, defence applications, safety at sea, ecological sustainability, and regional and global climate. See Annex IV for more information on BLUElink.

Freshwater resources

Historically, it has been a challenge to quantify at the national level how much water is available in river and storage systems across Australia. Water data are collected by a range of local, state and federal agencies as well as private organisations. These data have not been freely exchanged and have often been inaccessible. A nationally coordinated approach is now being implemented with the Bureau of Meteorology, which is at the centre of this data management process. This is a 10-year program, which should lead to an improvement in the international provision of data. Some data will be available online from early 2010.

8.5.2 Data collection, management and access

The **Bureau of Meteorology**, as the coordinator of Australia's GCOS-related activities, endorses World Meteorological Organization Resolution 40 in its policies on sharing data. The bureau is committed to supporting the GCOS Global Climate Monitoring Principles. It employs a comprehensive set of metadata practices, such as site and equipment documentation, overlap observations, instrument test reports and data management systems, to satisfy the GCOS principles while keeping pace with changes in technology.

Several external factors affect the integrity of long-term climate stations. The most important are changes in site exposure due to natural environmental development, and finding local observers in rural and peri-urban sites to continue observations. The bureau is updating site lease provisions and relocating stations where possible. Over the past decade many manual observing sites have had an automatic weather station installed nearby to help preserve the record of essential climate variables.

The bureau puts significant effort into maintaining the long-term climate record of meteorological data. Much of its historical records are now in digital form and available for use. However, financial constraints have thus far reduced opportunities to digitise pre-1957 daily and sub-daily synoptic records. Australia is also working collaboratively with Pacific island countries to rescue and digitise their data. These projects also help countries to build capacity in maintaining their climate records.

The **Cape Grim Baseline Air Pollution Station** detects atmospheric changes as part of a scientific research program jointly supervised by CSIRO's Marine and Atmospheric Research Division and the Bureau of Meteorology. Located in remote north-western Tasmania, the station provides vital information about changes to the atmospheric composition of the southern hemisphere. Extensive data are collected for use in studies of sources and sinks of greenhouse and ozone-depleting gases and in assessments of likely future atmospheric concentrations.

8.5.3 Capacity building

The **Pacific Islands – Climate Prediction Project**, which is funded by AusAID and managed by the Bureau of Meteorology, seeks to enhance the capacity of Pacific island national meteorological and hydrological services in seasonal climate forecasting and build their expertise in the prudent use of those forecasts.

Strategies include developing tailored climate prediction software for each participating Pacific island country, conducting training workshops and forums, and implementing pilot projects to assist in developing industry-specific climate predictions and appropriate management responses. The pilot projects cover a broad range of agencies and industries whose interests are affected by climate change and seasonal climate variability, including agriculture, renewable energy, water management, water security, and health.

A PC-based seasonal climate prediction statistical model called SCOPIC (Seasonal Climate Outlook for the Pacific Island Countries) was designed under the project for the Pacific island countries. Staff of national meteorological and hydrological services in 10 Pacific island countries (Cook Islands, Fiji, Kiribati, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu) participated in training workshops on SCOPIC and climate seasonal forecasting. See 9.6.1 for more information.

Under the banner of two specific projects—Pacific Islands Climate Data Rescue and Building Robust Infrastructure—the Bureau of Meteorology has been working in cooperation with participating Pacific island countries to ensure that collected weather

records, both hard copy and electronic format, are protected and preserved for use in climate change analysis, research and forecasting in the Asia–Pacific region and globally.

The projects are using Climsoft, a self-contained climate database management system that enables records to be kept locally in a structured and organised manner. Officers from the Bureau visited the Pacific island countries, installing Climsoft and instructing local officers in its operation and use. Continued support will be required to consolidate this initial training, and to update and make changes to the software to meet individual requirements.

Much of the work under the projects is aligned with GCOS principles and requirements, as many of these island sites form part of the GCOS Surface Network (GSN) and Upper Air Network (GUAN). Each country's meteorological agency has been briefed on GCOS issues relating to observational practices, supply and availability of equipment and the continued support of the Australian Bureau of Meteorology. The bureau's officers monitor GSN and GUAN outputs in Region V (the south-west Pacific) and provide advice and information on related matters in this region to the GCOS secretariat and the World Meteorological Organization.

This work will ensure that Pacific island nations are able to better manage their meteorological observations through improved systems and to provide better climate-related services and information to government, industry and the general population.

8.5.4 Palaeoclimate data

Planning for future climate change in Australia requires a level of understanding of our past natural climate variability that is beyond the scope of 20th century observational data. Australian researchers are involved in a number of ongoing palaeoclimate studies.

El Niño – Southern Oscillation

One study focuses on improving the understanding of past variability in the El Niño – Southern Oscillation (ENSO), which is particularly useful in assessing the significance of recent observed changes to ENSO and in determining the reliability of coupled climate model simulations. Using tree-ring, coral and ice-core data, the researchers reconstructed a proxy-based ENSO index for AD 1525 to 1982. The study used ENSO-sensitive proxies from across the Pacific to provide a more robust proxy ENSO signal. The common signal recorded in the multi-proxy network has a high correlation with the Southern Oscillation Index, Niño 3.4 Sea Surface Temperature and a combined ocean-atmosphere ENSO index (CEI). The CEI classification scheme was devised to identify synchronous oceanic and atmospheric (Southern Oscillation Index) anomalies associated with ENSO for the instrumental period (1871–2003). The proxy ENSO index also displays skill in reproducing warm and cold extremes of the Southern Oscillation Index.

The study also presents a spectral analysis of the proxy ENSO index over the last 450 years, which shows considerable amplitude and frequency modulation in the three- to 10-year band on multi-decadal timescales. There is a relative reduction in the amplitude of high-frequency variability during the 16th, early 17th and mid-18th centuries. In contrast, high-frequency ENSO variability has increased over the last 200 years.

Australia's long-term climate history

Historical archives are a rich resource for developing an understanding of Australia's climate history and its impact on past societies. A robust record of Australia's past climate is essential for putting into historical context extreme events like the current drought gripping southern Australia, providing valuable insights into Australia's past natural rainfall and temperature variability, and establishing a context for estimating the accuracy of climate change projections. Researchers at the Australian National University are looking at whether the recent dry conditions in southern Australia reflect an extreme event within the range of natural climate variability or whether the climatic baseline has shifted. Much longer duration records of natural rainfall variability are needed to resolve this.

Speleothem research

Speleothems (cave stalagmites) represent the best terrestrial archives of high-resolution palaeoclimate information for southern Australia because they record oxygen isotope and trace element variations. Speleothems preserve a record of rainfall variability over thousands of years through rainfall isotopes (linked to rainfall characteristics including amount), which are preserved in the speleothem calcite, as are trace elements reflecting the amount of soil and rock weathering and vegetation activity. Research projects are currently under way to reconstruct speleothem-based proxy records of natural rainfall variability in

south-west Western Australia (Perth and Margaret River regions), and the Wombeyan Caves and Yarrangobilly Caves in New South Wales. These sites are key water resource regions that are simultaneously experiencing high water demand and climate change. Variations in the aforementioned geochemical signals between wet and dry years have been proven at all sites by comparing drip water and modern speleothem geochemical variations against the instrumental record. Work is nearing completion on high-resolution (seasonal to sub-decadal) rainfall proxy records at these sites that will extend our knowledge of natural variability 1000 years back in time.

8.5.5 Atmospheric essential climate variables

The tables in Annex IV contain the data responding to the specific requirements in the UNFCCC reporting guidelines and the responses to the specific points on atmospheric, ocean and terrestrial essential climate variables.

Global atmospheric products requiring satellite observations

While Australia is not a satellite operator, it is highly dependent on satellite data for monitoring the state and composition of the atmosphere. Australia operates an extensive network of satellite reception stations and makes extensive use of indirectly received data.

In 2009, the Australian Government established a Space Policy Unit to formulate national space policy, including policy on earth observations, and to administer a space research grants program. This unit is expected to drive a whole-of-government approach to the acquisition, utilisation and archiving of satellite data and facilitate closer collaboration between agencies.

The Bureau of Meteorology contributes the data from its ground stations to international satellite data exchange through the World Meteorological Organization Space Programme.

A recent Bureau of Meteorology project has used digitised negatives and digital data provided by the Japanese Meteorological Agency to extend the record of geostationary imagery over the Australian region back to 1981.

Australia holds comprehensive records of full-resolution Advanced Very High Resolution Radiometer (AVHRR) data from the National Oceanic and Atmospheric Administration satellite series for Australian sites including Antarctica. These records are unique and are shared between national agencies.

In addition the following activities are planned:

- The Bureau of Meteorology will use satellite sounder radiances for upper-air observations, and will archive hyperspectral radiances for future use in monitoring atmospheric composition.
- The Bureau of Meteorology will record profiles from global positioning system (GPS) radio occultation, providing a bias-free observation of upper-atmospheric temperature and moisture.
- The Bureau of Meteorology and Geoscience Australia will collaborate on the derivation of total column water vapour from surface GPS networks.

Global products requiring satellite observations—oceans

In addition to in situ observations, Australia is dependent on satellite observations to monitor its surrounding oceans. The Bureau of Meteorology and CSIRO currently archive direct broadcast and imported satellite data, and produce a number of products in the following areas:

- altimetry (a measure of altitude)—processing and archiving altimetry data
- sea-surface temperature—high-resolution datasets created and being recreated from unique Advanced Very High Resolution Radiometer (AVHRR) archives
- ocean colour—archiving multi-spectral Moderate Resolution Imaging Spectroradiometer (MODIS) imagery.

A new system for monitoring sea ice using MODIS data is under development at the Antarctic Climate and Ecosystems Cooperative Research Centre.

Global products requiring satellite observations—terrestrial

As a large continent, Australia is dependent on satellites for some aspects of terrestrial observation. The unique AVHRR direct broadcast record, of approximately 18 years, is being used to create a time series of Normalised Difference Vegetation Index and other land-cover products.

The time series of geostationary satellite–derived daily solar exposure now extends back to January 1990. Other planned activities include:

- mapping small water bodies using high-resolution imagery
- work on fire disturbance
- work on soil moisture problems
- generation of monthly climatologies of solar exposure from geostationary satellites.

New relationships between terrestrial, bathymetric and satellite-derived height datasets

In 2009 Geoscience Australia began research to better understand the relationships between terrestrial, bathymetric and satellite-derived height datasets in collaboration with the Bureau of Meteorology's National Tidal Centre and the Cooperative Research Centre for Spatial Information. The reconciliation of these datasets is an essential component of any future effort towards an integrated national digital elevation framework that seamlessly incorporates height data across the land–sea interface. Enabled by this research, new seamless datasets will support improved prediction of inundation resulting from sea-level rise, storm surges, tsunamis and coastal erosion. A new tidal analysis software system has been developed to facilitate the research.

National Dynamic Land Cover Map

The first draft of the National Dynamic Land Cover Map has been prepared from remote-sensed satellite imagery and is currently under review. The map provides a baseline against which future land cover changes from climate influences can be assessed.

Land cover maps for the National Carbon Accounting System

Geoscience Australia has provided the Department of Climate Change with continental coverage of Landsat satellite imagery. Since 1999, some 16 epochs spanning 1972 to 2007 have been provided for use in the National Carbon Accounting System. The Landsat imagery is processed by the Department of Climate Change to provide spatially and temporally consistent land cover change mapping. This information is used in the National Carbon Accounting System to account for greenhouse gas emissions and removals from land-use change in Australia.

Satellite imagery for the International Forest Carbon Initiative

The International Forest Carbon Initiative is a key part of Australia's leadership on reducing emissions from deforestation and forest degradation in developing countries. Australia is providing satellite imagery to several south-east Asian countries to support their efforts to measure and account for greenhouse gas emissions from forests.

8.5.6 Oceanographic observations

The majority of Australia's ocean observing systems are described in 8.5.1 and Annex IV.

The **National Tidal Centre** specialises in sea level monitoring and analysis for the purpose of deriving trends in absolute sea level and producing national tide predictions, tide streams and related information. The centre provides management and operational support to the Australian Baseline Sea Level Monitoring Project, whose mission is to monitor changes in sea level around Australia. It involves the operation and maintenance of an array of high-resolution sea-level gauges and associated meteorological instruments and management of a quality-controlled national database of observations that is made available to the scientific and wider communities.

The **South Pacific Sea Level and Climate Monitoring Project** is funded by AusAID and managed by the Bureau of Meteorology. Geoscience Australia provides the **geodetic monitoring component** of the project and operates a network of 12 continuous global positioning system receivers throughout the South Pacific to monitor land motion at sea-level tide gauges. Motion in the earth's crust is known to contaminate relative sea-level observations and the geodetic measurements are modelling this effect to support improved climate and sea-level change studies.

References

CSIRO & BoM (Bureau of Meteorology) 2007, *Climate Change in Australia: Technical report 2007*, CSIRO, Melbourne.

Office of Climate Change (Qld) 2008, *Climate Change in Queensland: What the science is telling us*, Environmental Protection Agency, Brisbane.

Poloczanska, ES, Hobday, AJ & Richardson, AJ (eds) 2009, *Marine Climate Change in Australia: Impacts and Adaptation Responses—2009 report card*, National Climate Change Adaptation Research Facility, available at www.oceanclimatechange.org.au.

CHAPTER 9

Education, training and public awareness

Photo: Senator the Hon. Penny Wong, Minister for Climate Change and Water, and the Hon. Kevin Rudd, MP, Prime Minister of Australia, with winners of the 'Think Climate, Think Change' schools competition, announced in August 2009, with (left to right) Krystal Van Schoon Hoven (Manchester Primary School, Victoria), Isabella Compton (Our Lady of the Rosary Primary School, New South Wales) and Michelle Aitken (John Curtin College of the Arts, Western Australia).

KEY DEVELOPMENTS

Since Australia's Fourth National Communication:

- Australian governments at all levels have developed public awareness campaigns, tools and educational materials to educate and inform the community and build broad support for climate change policies.
- Reforms and program delivery through Australia's formal education system and the vocational education and training sector will ensure that Australia's current and future workforce will be equipped with the ingenuity, skills and knowledge to respond to climate change and to facilitate the transition to a lower-carbon economy.

The Australian Government recognises that information and education are fundamental to building broad support for climate change policies. Australian governments at all levels—national, state, territory and local—have developed public awareness and education programs to communicate the need to change behaviours that contribute to climate change. At the community level, there are a broad range of research, environment, welfare and other non-government organisations that promote public awareness and understanding of climate change through research, lobbying, education, training and media activities.

Stakeholder engagement is central to developing, implementing and evaluating effective climate change policies. The Australian Government has consulted with key stakeholders, including industry, non-government organisations, the science community, other experts and the public, to gain essential feedback and to assist the community to understand current and emerging climate change policies and programs.

In addition, climate change will create new challenges and opportunities for Australia's industries, labour market and education and training systems, and will impose new obligations on them. The transition to a lower-carbon economy will require a restructuring of existing approaches to activities such as those involved in production, transport, distribution and consumption. Human ingenuity, skills and knowledge, and a commitment to environmental sustainability, are important elements of climate change strategies and actions. Therefore, the Australian and state and territory governments are working to identify skill needs, reform training products, and deliver training to upskill and reskill the workforce. Those measures will build the capacity of the workforce to respond to climate change and make the transition to a lower-carbon economy, while ensuring that Australia has enough skilled workers to avoid the economic costs and inflationary pressures created by skills shortages.

9.1 Education and training

Under Australia's federal system of government, state and territory governments have responsibility for education and training. They are also responsible for funding the vocational education and training sector, while the Australian Government has primary responsibility for public funding of the higher education sector.

The Australian Government has a leadership role in identifying and promoting national standards and priorities for students. In 2008, all Australian education ministers agreed to the National Declaration on Educational Goals for Young Australians, which frames state and territory curriculum policies and articulates a national vision for schooling. The declaration states that Australians must be able to engage with scientific concepts and principles and approach problem-solving in new and creative ways to respond to complex environmental, social and economic pressures, such as climate change.

Since 2008, the Australian Government has rolled out an 'education revolution' to improve educational outcomes and productivity. These reforms will involve collaboration across the public and private sectors and a genuine partnership of parents, children, students, employers and all levels of government. The Government is also consulting broadly to develop a new national curriculum in English, mathematics, the sciences and history, to be introduced in 2011, which will advance higher standards in schooling through greater national consistency.

These national-level initiatives, once consolidated, will create a high-level framework that will equip students with the analytical and problem-solving skills needed to understand climate change and other significant national and global issues.

All levels of Australia's education and training system including primary and secondary schools, universities and the vocational education and training sector are embedding the principles, knowledge and skills required to foster long-term sustainability and prepare for climate change.

9.1.1 Schools

The Australian Government is helping schools to prepare for climate change and build for the future by providing educational resources and renewable energy grants. These school-based programs will build Australia's capacity to meet the skills challenges posed by climate change, support young people's learning and skills development, and aid their transition to full participation in a future workforce affected by climate change.

The Australian Sustainable Schools Initiative (AuSSI) is a partnership of the Australian Government and state and territory governments to encourage sustainability in schools and the communities they serve. AuSSI involves participants in a whole-of-school approach to improve the management of resources and facilities, including energy, waste, water, biodiversity, landscape design, products and materials. More than 2000 schools are now participating in the initiative. They have reported up

to 80% reductions in waste collection, 60% reductions in water consumption and 20% savings on energy consumption, with commensurate reductions in greenhouse gas emissions.

The Global Communities for Sustainability (GCS) project involves school-driven sustainability collaborations with local councils and key community organisations in Australia and India. The pilot phase of the GCS project, which involved the states of New South Wales in Australia and Gujarat in India, was completed successfully in 2008. Schools in both countries chose GCS ambassadors, who visited the other country to share knowledge and interact with other participating schools. In 2009, the GCS project is being supported by the Australian Government and is being mainstreamed through AuSSI.

The Vocational Education and Training (VET) in Schools initiative is a partnership between schools, training providers and industry designed to help prepare students for the transition to employment, further education or training. The training delivered through VET in Schools programs is designed to respond to current industry demand for new skills. As the 'green' industry sector grows and matures, new industries and technologies will emerge and existing industries will adapt to a sustainable future and demand new skills.

The National Solar Schools Program offers grants of up to $50 000 to enable Australian schools to improve their energy and water efficiency and reduce ongoing energy costs. The grants support the installation of solar power systems, rainwater tanks and a range of renewable energy and energy efficiency measures. For extra electricity and greenhouse emissions savings, schools can sell surplus electricity generated by solar power systems on weekends and during school holidays back into the electricity grid. There has been strong interest in the program. More than half of all Australian schools have registered to participate, and more than 1800 of them have had their grant applications approved. The high participation rate resulted in the allocation of the program's entire 2009–10 budget by mid-October 2009.

The Australian Academy of Technological Sciences and Engineering has developed the national Science and Technology Education Leveraging Relevance Program, which is a 6- to 10-week program, to be provided free of charge to 150 secondary schools across Australia in 2010. The program aims to foster understanding among grade 9 and 10 students as to how science and mathematics can be used to fight climate change.

THINK CLIMATE, THINK CHANGE SCHOOLS COMPETITION

The Department of Climate Change character Marty, the spotted-tail quoll.

To help young people understand and combat climate change, and share their ideas with Australia, the Australian Government Department of Climate Change ran the Think Climate, Think Change Schools Competition. The department worked closely with an external educational material development agency to create and distribute all competition material. Printed resource packs containing competition information, entry forms and 'fast facts' on climate change were sent to 11 500 primary and secondary schools across Australia and made available to schools via the internet.

Students enrolled in Australian schools and home-schools in grades 3 to 9 were asked to use their creative talents to answer the question, 'What does climate change mean to me?' Common themes that students wrote about included:

- what the environment was like in the past and what it will be like in the future if we do not act now
- the causes of climate change and possible solutions
- the different aspects of the climate change problem and the variety of solutions needed
- the role we can all play in combating climate change.

A national winner, two runners-up and three highly commended entries were chosen from each category. On 12 August 2009, the winners were announced by the Minister for Climate Change and Water and the Deputy Prime Minister at an awards ceremony in Canberra. The education project was evaluated to be a success, as evidenced by the large response to the competition from youth (7839 entries) and the significant support from their teachers and parents.

9.1.2 Universities

The Australian higher education sector consists of 37 public universities, two private universities and about 150 other accredited higher education providers.

Universities are responding to industry and student demand by providing undergraduate and postgraduate qualifications and short courses for climate change professionals. In this relatively new field, interdisciplinary research and coursework programs are common at the undergraduate and graduate levels. Course options include environmental management and planning; environmental science; climate change science; climate change vulnerability and adaptation; and environmental studies.

Four major Australian universities have formed the Australian University Climate Consortium and are integrating their climate research and education programs to provide a world-class, strategic, team-based climate science capability for Australia. The consortium consists of the Australian National University, Monash University, the University of Melbourne and the University of New South Wales, each of which includes recognised world-class research leaders among its staff. About 80% of Australia's nationally significant university-based teaching and research on climate-related issues occurs at these four universities.

9.1.3 Vocational education and training

Australia's national training system includes publicly funded technical and further education institutions and privately funded training providers. The Australian VET sector delivers post-compulsory education and training to build specific occupational or work-related knowledge and skills. VET sector training is provided through a national network of more than 4000 registered training organisations and is funded from a mix of public, private and industry sources.

The Australian Government and state and territory governments are working together to enable the VET sector to develop specific education and training to address the growing industry demand for 'green' skills and, ultimately, to help achieve a more environmentally sustainable, more productive and lower-carbon economy. The National VET Sector Sustainability Policy and Action Plan 2009–2012 is Australia's national framework for VET sector development.

A range of Australian government programs are in place to enable Australians to join new clean industries and take up the new green-collar jobs of the future, such as the Skills for Carbon Challenge, the Clean Sustainable Skills Package and the Skilling Australia for the Future programs.

The Skills for the Carbon Challenge program provides incentives for Australians to develop skills for sustainability. The program builds the capacity of the VET sector to supply the skills needed to implement government climate change mitigation and adaptation strategies. Skills for the Carbon Challenge also supports the development and trialling of qualifications and training resources in key industries such as plumbing, heating, ventilation and air conditioning; the establishment of a voluntary certification program to recognise registered training organisations providing training in skills for sustainability; and green training awards to encourage excellence.

The Clean Sustainable Skills Package aims to start building green skills and jobs today and to embed clean, sustainable skills in all areas of the economy and the national training system. The package includes:

- the National Green Skills Agreement, which will ensure that trade apprentices who begin their training after 1 January 2010 will graduate with a core set of green skills and knowledge
- the provision of 10 000 environmental work experience and training places for job seekers, from 17 to 24 years of age, to gain job-ready skills through the National Green Jobs Corps
- fully funded training places to support 4000 workers involved in installing ceiling insulation
- a green jobs initiative to support an estimated 6000 new local jobs contributing to environmental sustainability in 20 priority regions targeted by the Jobs Fund, a national job creation initiative.

The Australian Government's Skilling Australia for the Future policy is designed to position the nation to gain the changing skills needed to address climate change. A total of 711 000 new training places are being delivered through the Productivity Places Program to respond to current and emerging skills shortages. Of those, 392 000 will be allocated to workers who want to gain new skills or upgrade their current skills, and 319 000 will be allocated to job seekers. The state and territory governments progressively assumed delivery of training places during 2009, as agreed in a national partnership agreement negotiated through the Council of Australian Governments.

State and territory governments are also collaborating with industry and VET sector training providers to develop education and training programs that build skills and enhance awareness of principles of sustainability and energy efficiency in key trades and industries. For example, the New South Wales Government established the $20 million Energy Efficiency Training Program to develop and deliver energy-efficiency and renewable energy education and training for key trades and professions and ensure that the state's workforce has the skills and knowledge to support the transition to a lower-carbon economy. The program has three components: development and delivery of VET courses for tradespeople and professionals; professional development for trainers and for professions; and industry partnership projects to ensure the take-up of training in key industry sectors.

The Queensland Government established the Green Building Skills Fund, which is designed to boost sustainability expertise in Queensland's building and construction industry. The Queensland Government has partnered with peak industry bodies to deliver accredited training courses, with a particular emphasis on training in regional Queensland. The fund will subsidise 50% of participants' course costs, resulting in around 3000 training places over four years.

9.1.4 Professional training and development

A range of government initiatives address the demand for ongoing development of professional skills and knowledge relevant to climate change.

The Australian Government's Climate Change Adaptation Skills for Professionals Program is providing grants to 12 professional associations, training organisations and tertiary institutions to integrate climate change study into education and training for professionals. The program is geared to professionals with crucial roles in building Australia's capacity to adapt to a changing climate, such as engineers, architects, natural resource managers and planners. With broader and deeper knowledge of climate change, they will be able to choose appropriate and practical adaptation strategies that reduce the vulnerability of settlements, infrastructure, natural ecosystems and water resources to the impacts of climate change.

The Primary Connections, Science by Doing and Scientists in Schools programs provide effective models of professional learning for primary and secondary teachers in the sciences. Professional development is also a component of the Australian Sustainable Schools Initiative.

The New South Wales Government designed the Sustainability Advantage program to bring together businesses with shared regional, industry or supply-chain interests and help them boost their environmental performance. The program provides access to training, workshops, technical assistance and networking over 18 months to enable businesses to share their experiences and learn from the experiences of other companies.

9.2 Industry

The Australian Government maintains strong lines of communication with key industry and non-government organisation stakeholders on specific policy issues and developments in international climate change negotiations. For example, for each major round of negotiations under the UNFCCC, the Government provided industry briefings on key developments and the focus of the Australian Government's efforts. The briefings were complemented by briefings convened for Australian stakeholders by the Ambassador for Climate Change during UNFCCC negotiations. As the pace of negotiations increased in the lead-up to the December 2009 United Nations Climate Change Conference in Copenhagen, the Government briefed stakeholders in meetings before each negotiating session. The Department of Climate Change also publishes Australian UNFCCC submissions on its website.

The Government has established the $2 billion Climate Change Action Fund to provide targeted assistance to business, community sector organisations, workers, regions and communities, helping to smooth the transition to a low-emissions economy. As part of the Climate Change Action Fund, the Government has allocated $20 million to a business information package that will provide advice to business on the operation of the Carbon Pollution Reduction Scheme and identify potential opportunities and impacts that may arise. The information package will be developed in close consultation with business groups and will harness the expertise and networks of these representative bodies.

A key focus of the Australian Government's National Agriculture and Climate Change Action Plan is to improve the understanding of climate change issues by Australian agricultural industries and rural communities to enable them to make informed

decisions. Under the action plan, the Government will develop educational brochures, briefing materials and web pages on the Australian climate and deliver information in training and briefing sessions in the southern Australian states in partnership with state agricultural departments and rural advisers.

At the state level, other examples of business involvement are:

- Grow Me The Money, a program developed by the Victorian Employers' Chamber of Commerce and Industry and Environment Protection Authority Victoria, which provides online tools, information and education material to small- to medium-sized businesses to help them become more sustainable and save money
- Carbon Down, a partnership between the Victorian Employers' Chamber of Commerce and Industry and the Victoria Government, which was developed to help Victorian businesses reduce their carbon footprint through behavioural change and knowledge sharing.

Industry-driven conferences and trade fairs, such as Carbon Market Expo Australasia 2009, also provide forums for sharing information on and raising awareness of the obligations and opportunities created by the transition to a lower-carbon economy. The expo brought together domestic and international carbon market participants and service providers to develop strategies to minimise costs and maximise benefits from the introduction of the Carbon Pollution Reduction Scheme.

9.3 Non-government organisations

A broad range of non-government organisations promote public awareness and understanding of climate change through research, lobbying, education, training and media activities. Such efforts at the community level have made significant contributions towards broadening the awareness of the Australian public of the significance of climate change. These non-government organisations cover all sectors of the Australian economy, ranging from industry and business organisations, to conservation, research and welfare organisations. A few examples are provided below.

Organisations such as the Climate Action Network Australia and ClimateWorks facilitate informed dialogue and foster coordinated action on climate change, either directly or by stimulating action by other philanthropic, government, business and academic stakeholders.

The Australian Youth Climate Coalition and World Vision Australia encouraged young Australians to have their say though a national youth vote on climate change in 2009. In the week-long ballot, 37 432 young Australians cast their votes, making Youth Decide one of the world's biggest per capita mobilisations of young people on climate change.

Environmental and climate research organisations such as Earthwatch and The Climate Institute undertake non-partisan, independent research, education and communication activities and work with the community, businesses and government to promote understanding and drive effective climate change solutions.

Community-based environmental organisations such as the Australian Conservation Foundation and WWF Australia run climate change campaigns 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.

The Australian Football League (AFL) developed the AFL 'Green Round' initiative, to promote action that football fans and players can take on climate change while watching or playing their favourite game. For example, when leaving home for the game, fans are encouraged to switch off their lights and appliances and to use public transport, cycle or car pool to get to games.

In addition, numerous welfare organisations are providing assistance to disadvantaged and low-income groups to reduce their environmental footprint and save money on household energy bills. Welfare organisations are also building the capacity of disadvantaged sectors such as the long-term unemployed to take up the employment opportunities that will inevitably emerge out of the new, greener industries. Organisations in the welfare and social justice sector are also working to address the social impacts of climate change. For example, welfare groups based in farming and rural communities are already providing assistance to families that are experiencing the impacts of the prolonged drought and climate change through the degradation of family and business financial security.

9.4 Public awareness raising

The success of actions to address climate change will depend, in part, on engendering a shared responsibility for climate change across all levels of government and the broader Australian community, including industry and Australian households. To ensure Australians are informed on the issue and are able to engage meaningfully in responses to it, the Australian Government and state and territory governments have undertaken a range of activities to broaden public awareness of climate change.

9.4.1 Joint initiatives

The Garnaut Climate Change Review was commissioned in April 2007 by the eight state and territory governments of Australia and the then leader of the federal opposition; the Australian Government joined the Garnaut Review in January 2008. The Garnaut Review examined the impacts of climate change on the Australian economy and to recommend medium- to long-term policies and policy frameworks to improve the prospects of sustainable prosperity. As part of its research and analysis, the Garnaut Review consulted with a wide range of experts and stakeholders in Australia and overseas: academics; officials; government departments and public bodies; business leaders and representatives; and non-government organisations. The Garnaut Review commissioned a number of reports on the impacts of climate change on Australia, which represent major contributions to the growing body of knowledge about these impacts.

The Garnaut Review benefited substantially from interactions with other organisations and the community more generally at specialist forums and other public forums and lectures held around the country between August 2007 and September 2008. More than 10 000 people participated in these events over the course of the review. The Garnaut Review was subject to intense media attention and gained a high profile, which further broadened community awareness of climate change and encouraged lively public debate.

9.4.2 Australian Government initiatives

From July to October 2008, the Australian Government ran the *Think Change* advertising campaign as part of a broader communications program designed to support the implementation of the Government's climate change policies, inform Australians, and support their engagement on this important issue. The campaign actively worked towards putting climate change on the radar of the Australian public and raised awareness and understanding of the importance of climate change, how it would impact Australia, and the need to take action to address this issue. It informed the community about the Carbon Pollution Reduction Scheme, and invited the public to contribute to the policy development process for this major reform.

In December 2008, the Australian Government released a White Paper on the Carbon Pollution Reduction Scheme, which explained the design elements of the proposed scheme, Australia's medium-term target range for reducing greenhouse gas emissions and measures to assist households and industry to adjust to the impact of the carbon price. Following the release of the White Paper, the Government held public information sessions in state capitals and regional centres. An information session for regional Australia, broadcast live around the nation on satellite TV, was held in February 2009. The White Paper is available on the Department of Climate Change website.

The Australian Government has instituted Community Cabinet meetings to allow regular direct engagement with the community on important questions. Community Cabinet meetings are held in a different electorate every month and typically start with a public forum and conclude with questions from the floor. In recent forums, members of the public have asked the Prime Minister to explain how the proposed Carbon Pollution Reduction Scheme will affect the community, and have been particularly interested in the cost of energy and the level of assistance to be provided to low-income earners and pensioners. Community Cabinet has also given the public an opportunity to find out more about progress on the Government's commitments to deliver targeted emissions reductions.

The Australian Bureau of Statistics oversees a number of programs which include energy statistics, environmental accounts and a range of survey programs across businesses (including agriculture) and households. Since Australia's Fourth National Communication, the bureau has released publications on electricity and gas supply activity, people's views on environmental issues, and energy and water use by farms, businesses and households.

Source:
Victorian Government ResourceSmart,
www.saveenergy.vic.gov.au.

9.4.3 State and territory programs

State and territory governments' public information campaigns tend to focus on driving behavioural change in the community. The campaigns inform people about simple actions they can take to save energy, reduce water use and minimise waste in their daily lives.

The Victorian Government's Black Balloons awareness campaign promoted household energy efficiency. The campaign was designed to promote behavioural change in the Victorian community by making people aware of the simple steps they can take to reduce their energy use and prevent almost three million tonnes of greenhouse gases from entering the atmosphere each year. The Black Balloons campaign was subsequently adopted by the New South Wales, Queensland and South Australian governments. The South Australian Government commissioned an independent evaluation of its Black Balloons awareness campaign that indicated significant improvements in community awareness of climate change and what can be done to reduce greenhouse gas emissions.

The New South Wales Government's Energy Efficiency Community Awareness Program is designed to provide practical advice to the community on how to save energy at home and work. The government has established the Save Power web portal for this information.

The New South Wales Government's FleetWise Partnership provides tailored information and tools to businesses, not-for-profit organisations and local councils that operate vehicle fleets to help them reduce emissions of greenhouse gases and other air pollutants.

The Queensland Government's TravelSmart Workplaces and Events program is designed to reduce emissions by promoting the use of alternative modes of transport such as cycling, carpooling and public transport. The program will provide web-based tools and information to assist workplace managers and major event organisers to develop sustainable travel plans. The similarly designed TravelSmart Schools program will assist participating schools to develop and implement school travel plans tailored for their community by providing seed funding, tools and information. Both programs offer support to participants from a dedicated Travel Smart case manager.

In 2007–08, the Queensland Government's Climate Smart Living (phase 1) campaign issued four 'calls to action' to the Queensland community to take action to reduce energy consumption and greenhouse gas emissions. The program encompassed four specific campaigns including 'Change a Light Bulb Day', 'Cool it by Degrees Day', and 'Climate Under Pressure Month'. The Queensland Government's Climate Smart Living (phase 2) program uses a mix of communication mediums, including advertising, events, sponsorship and community partnerships, to engage individuals, households and communities and drive behavioural change to reduce carbon emissions.

The Queensland Government's Climate Smart Living campaign incorporates the Low Carbon Diet behavioural change program, which is a designed to help Queenslanders reduce their carbon footprint at home and in their communities. The initiative is supported by a small grants program to assist not-for-profit and community organisations to cover their administrative and delivery costs.

In 2008, the Queensland Government published *Climate Change in Queensland: What the science is telling us*, which summarises the latest peer-reviewed science on climate change and broadens understanding among governments, businesses, communities and individuals.

Western Australia's LivingSmart program gives the community information on how to reduce greenhouse gas emissions in daily travel and in the home such as through the use of energy-efficient appliances. The TravelSmart program encourages people to use their cars less and to choose alternative transport options, such as walking, cycling and public transport. TravelSmart has delivered an average 10% reduction in car trips and 13% reduction in car kilometres in targeted suburbs.

The South Australian Government's Green Hubs Community Engagement Program was designed to utilise existing community hubs and their networks to reduce the environmental impacts of clubs and workplaces and assist members to reduce their

individual greenhouse emissions. An evaluation of the pilot, undertaken by the University of Adelaide, found that the program's focus on practical strategies and solutions to environmental concerns was highly valued by participants. The program has subsequently been extended.

The Tasmanian Government's Earn Your Stars Community Awareness Campaign uses advertising and web-based tools to encourage the Tasmanian community to better appreciate the link between climate change and their actions. The campaign focuses on empowerment and aims to demonstrate the small things that everyone can do to improve their household and workplace energy efficiency, reduce waste and cut transport emissions.

The Tasmanian Government's Earn Your Stars Micro-Grants Program provides grants of up to $3000 to community groups to undertake small-scale projects in their communities to encourage awareness of climate change and provide practical tools to help others reduce their greenhouse gas emissions and conserve energy.

9.5 Public access to information

Australians are looking for information and action on the changing climate, so providing and disseminating knowledge is a key part of building Australia's response to climate change. The Australian Government and state and territory governments have supported the development of online information, tools and resources that individuals, communities and business groups can access to help them understand climate change and to facilitate direct action to address climate change.

9.5.1 Public resources and information

Government websites such as the Department of Climate Change website are regularly updated to provide the Australian public with the latest information about government action on climate change and to help stakeholders and the general public better understand the purpose and requirements of climate change legislation and policies. Another example is the Bureau of Meteorology's website, which provides user-friendly summaries of historical and recent climate trends in Australia. Information from the website has been used widely in the media, in education and for research and study.

There are also specific online resources that are designed to help the Australian public navigate the substantial volumes of information on climate change and related issues. The LivingGreener website, for example, provides the Australian community with a single entry point to relevant federal, state and local government energy, water, waste and transport efficiency programs. The online portal makes it easier for Australians to access information about what they can do and what assistance is available to help them make better environmental decisions. The initial release of the site focuses on key Australian Government initiatives. In subsequent phases, the site will link to state, territory and local government information pages and provide a range of ancillary information to help Australians minimise their environmental footprint and save on energy bills.

State governments have designed programs to facilitate public access to information. The Victorian Government's ResourceSmart and the Queensland Government's ClimateSmart Business Service are two such examples. These initiatives provide online resources that offer a range of tailored solutions, ideas and practical advice for households, businesses, schools and government agencies that want to save energy and reduce water use and waste in their day-to-day operations.

9.5.2 Specialised and technical information

The Australian Government and state and territory governments have developed specialised or technical information, tools and resources to meet the requirements of businesses and individuals working in the commercial, industrial or agricultural sectors in technical roles such as engineers, marine scientists, planners or natural resource managers.

The Australian Government developed the Energy Efficiency Exchange, a website designed to provide information to businesses and individuals, either within or servicing the commercial and industrial sector, to increase the uptake of energy efficiency technologies and processes. The site is envisaged to become Australia's premier information portal for all companies in the industrial and commercial sectors looking for best practice information on energy efficiency. It is intended for a range of audiences including energy managers, process managers and engineers, commercial property managers and technical specialists.

The Smartline national coastline dataset was publicly launched and made available in 2009 through the OzCoasts website. The Australian Government's aim is to deliver an online web application for Australia,

consisting of coastal geomorphology and stability maps in segmented line format, together with beach information. Smartline was prepared as part of the National Coastal Vulnerability Assessment by Geoscience Australia, the University of Tasmania and other contributors.

The Coastal Management Education Assessment Tool was developed to build capacity in coastal management—an emerging field for national collaboration. As part of the development, the Australian Research Institute in Education for Sustainability carried out a research program that identified significant needs and gaps in coastal management education across Australia and opportunities for increasing the effectiveness of existing education programs.

The Queensland Government developed The Long Paddock website to provide climate management information to rural Queensland, such as seasonal climate forecasts and information on the Southern Oscillation Index, drought status and land management decision making.

9.6 International activities

A key focus area of the Australian Government's climate change agenda is sharing its experiences in implementing climate change policies to assist other counties, in particular developing countries, to measure and manage their emissions, to reduce emissions from key sectors and to adapt to the unavoidable impacts of climate change.

9.6.1 Knowledge sharing and capacity building

Australia values its close links with Pacific island countries and is committed to playing an active and constructive role on climate change in the region. The Government led the development of a whole-of-government Pacific climate change policy document, which will guide Australia's engagement with Pacific island countries on climate change to 2015.

The Australian Government is investing $150 million over three years from 2008–09 to 2010–11, through the International Climate Change Adaptation Initiative, to meet high-priority climate adaptation needs in vulnerable countries in the region. As one of the early steps in implementing the initiative, the Government announced the $20 million Pacific Climate Change Science Program to increase understanding of the drivers and impacts of climate change in the Pacific in order to enhance the basis for making adaptation decisions and to help target future development assistance.

The Australian Government's Pacific Islands – Climate Prediction Project funded training workshops in 10 countries (Cook Islands, Fiji, Kiribati, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu) from 2004 to 2007. Officers from the Australian Bureau of Meteorology delivered the in-country training and regional workshops, which enabled local national meteorological and hydrological services (NMHSs) to establish climate prediction services and initiate client networks.

The workshops covered seasonal climate forecasting and SCOPIC (Seasonal Climate Outlook in the Pacific Island Countries—a PC-based seasonal climate prediction statistical model designed under the project for the Pacific island countries). Australia continues to provide support to consolidate the initial training and to update the software as required.

An e-learning package covering SCOPIC and seasonal climate forecasting has also been developed and distributed to all NMHSs. The package provides instructions and reference information in a series of brief, self-paced, online modules on key concepts in climate prediction and the SCOPIC application. The package includes a seasonal climate outlook exercise, which includes a self-assessment test.

The *Quick Reference Guide to SCOPIC: How to produce a three-month outlook* was developed and distributed to all NMHSs. The guide provides step-by-step instructions on how to produce three-month rainfall outlooks using SCOPIC, and includes guidance notes and useful tips.

9.6.2 Research and scholarships

Australia's support for research to improve the capacity of developing countries to prepare for the impacts of climate change has grown significantly since Australia's Fourth National Communication. AusAID support for research relating to climate change rose from $1.5 million in 2006–07 to over $5 million in 2007–08 and over $6 million in 2008–09. The support is provided through various programs and initiatives, including:

- a research partnership with the Centre for International Forestry Research, which will collect and disseminate lessons about reducing emissions from deforestation and forest degradation (REDD) to inform the design and implementation of REDD activities

- the Mekong River Commission, which aims to generate policy-relevant information on the likely impacts of climate change on water and food security in the Lower Mekong Basin and to indicate potential adaptation strategies to reduce vulnerabilities
- the South Asia Water Initiative, which involves research to establish climate change scenarios for the river systems emanating from the Himalayan region
- a series of research projects on financial mechanisms and incentives for mitigating and responding to climate change.

Climate change is also one of the three focal areas of the AusAID – CSIRO Research Alliance, a research and development collaboration that aims to understand and mitigate unintended consequences of development in order to deliver new solutions to regional environmental challenges.

The Australian Government funds a range of research awards and scholarships that are open to developing countries. The Australian Development Research Awards are an important component of the Australian aid program's research strategy, and climate change was one of the awards' key themes in 2007 and 2008. Funding for awards addressing climate change rose from $292 201 in 2007–08 to $741 227 in 2008–09.

The Australian Leadership Awards have been designed by the Australian Government to increase access to, and the quality of, education and training for people in partner countries. The program's scholarships and fellowships are highly valued forms of development cooperation that contribute to long-term development, growth and stability. Candidates from more than 80 countries are eligible to pursue AusAID scholarships and participate in fellowship programs hosted by Australian organisations. Climate change is a priority area for scholarships and fellowships. In 2007–08, 31 scholarships and 34 fellowships relating to climate change were awarded, with a total value of $5.84 million. In 2008–09, 25 scholarships and 55 fellowships relating to climate change, with a total value of $6.35 million, were awarded.

9.6.3 Partnerships

At the heart of Australia's efforts to help shape a global solution to climate change is the quality and depth of our relationships with key developed and developing countries including the United States, China and Indonesia.

The Australian Government continues to support practical collaborative activities under bilateral partnership agreements. For example, a prototype to generate electricity from low-concentration coalmine methane, completed in 2009, will be demonstrated in China in the near future.

In 2008–09, government representatives worked with counterparts in Indonesia and Papua New Guinea to build capacity in these two countries to reduce emissions from deforestation and degradation, and assisted key developing countries to integrate climate change considerations into national development plans, including ways to develop and deploy renewable energy and low-emissions technologies.

The Australian Government also worked closely with Indonesia to implement early stages of the International Forest Carbon Initiative, which is focused on reducing emissions from deforestation and degradation, and is working in partnership with the Clinton Climate Initiative to deliver technical forest carbon workshops in Cambodia, Guyana, Kenya and Tanzania.

The Government has advanced existing partnerships and delivered more than 70 completed or ongoing projects and provided a positive framework for high-level engagement on policy issues and practical collaboration activities with key developing countries to help combat climate change.

In 2009, Australia and China renewed the Australia–China Memorandum of Understanding on Climate Change Activities. The memorandum of understanding focuses on:

- enhancing scientific understanding of climate change
- building capacity to adapt to the impacts of climate change
- developing opportunities in climate change technology, products and expertise.

Australia and China have signed a specific agreement for enhancing cooperation between the Department of Climate Change and China's National Development and Reform Commission to help implement the Australia–China Memorandum of Understanding.

The Australian Government is working to strengthen and capitalise on these relationships through its existing bilateral relationships and through constructive engagement in major complementary forums, including the Major Economies Forum for Energy and Climate Change and the Group of Twenty.

Annex I Trends in greenhouse gas emissions

Table AI.1 ***Greenhouse gas emissions (Gg CO_2-e) by sector and subsector in Australia, 2007***

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2-e (Gg)						
Total (net emissions)	**674 932**	**119 774**	**25 042**	**5 118**	**502**	**521**	**825 888**
1. Energy	**372 138**	**33 320**	**2 705**				**408 163**
A. Fuel combustion (sectoral approach)	365 978	1 853	2 679				370 510
1. Energy industries	220 972	234	638				221 844
2. Manufacturing industries and construction	48 347	53	261				48 661
3. Transport	76 482	589	1 703				78 774
4. Other sectors	18 629	975	68				19 672
5. Other	1 547	2	10				1 559
B. Fugitive emissions from fuels	6 160	31 467	26				37 653
1. Solid fuels	NA,NE	26 832	NA				26 832
2. Oil and natural gas	6 160	4 635	26				10 821
2. Industrial processes	**24 113**	**72**	**17**	**5 118**	**502**	**521**	**30 343**
A. Mineral products	5 867	NA	NA				5 867
B. Chemical industry	1 317	9	IE,NA,NO	NA	NA	NA	1 326
C. Metal production	10 542	63	17	NA	502	NA,NO	11 124
D. Other production	NE						NE
E. Production of halocarbons and SF_6				NA,NO	NA	NA	NA,NO
F. Consumption of halocarbons and SF_6				5 118	NA,NE,NO	521	5 639
G. Other	6 388	IE,NA	IE,NA	NA	NA	NA	6 388
3. Solvent and other product use	**NA**		**IE,NA,NO**				**IE,NA,NO**
4. Agriculture		**67 950**	**20 156**				**88 106**
A. Enteric fermentation		57 561					57 561
B. Manure management		1 859	1 594				3 453
C. Rice cultivation		196					196
D. Agricultural soils		NA,NE	15 002				15 002
E. Prescribed burning of savannas		8 122	3 463				11 585
F. Field burning of agricultural residues		211	98				309
G. Other		NO	NO				NO
5. Land use, land-use change and forestry	**278 652**	**4 484**	**1 574**				**284 710**
A. Forest land	–21 591	2 102	574				–18 916
B. Cropland	22 696	667	202				23 565
C. Grassland	280 519	1 715	469				282 703
D. Wetlands	IE,NE,NO	IE,NA,NE,NO	IE,NA,NE,NO				IE,NA,NE,NO
E. Settlements	IE,NE,NO	IE,NE	IE,NE				IE,NE,NO
F. Other land	NO	NO	NO				NO
G. Other	–2 972	NA,NO	329				–2 643
6. Waste	**29**	**13 949**	**590**				**14 567**
A. Solid waste disposal on land	NA	11 106					11 106
B. Waste-water handling		2 843	590				3 432
C. Waste incineration	29	NA	NA				29
D. Other	NA	NA	NA				NA
7. Other	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo items:							
International bunkers	11 882	3	110				11 994
Aviation	9 261	0	87				9 348
Marine	2 621	3	22				2 646
Multilateral operations	**NE**	**NE**	**NE**				**NE**
CO_2 emissions from biomass	**18 050**						**18 050**

Total CO_2-e emissions without land use, land-use change and forestry	**541 179**
Total CO_2-e emissions with land use, land-use change and forestry	**825 888**

Table AI.2 ***Trends in greenhouse gas emissions (Gg CO_2-e) by sector and subsector in Australia, 1990 to 2007***

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (Gg)	1990 (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	1995 (Gg)	1996 (Gg)	1997 (Gg)	1998 (Gg)	1999 (Gg)	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)	2005 (Gg)	2006 (Gg)	2007 (Gg)	Change from base to latest reported year %
Total CO_2-e emissions	453 794	453 794	550 728	483 049	423 603	385 260	542 447	430 800	400 461	602 093	**436 580**	**404 392**	**427 079**	**791 075**	**630 040**	**328 461**	**596 239**	**551 058**	**825 888**	**82.0**
1. Energy	**286 433**	**286 433**	**288 302**	**294 537**	**298 927**	**301 173**	**312 795**	**318 703**	**328 978**	**342 864**	**349 717**	**358 623**	**365 124**	**368 640**	**381 635**	**387 040**	**392 830**	**400 104**	**408 163**	**42.5**
A. Fuel combustion (sectoral approach)	257 226	257 226	259 527	264 108	268 134	271 418	281 715	289 372	297 806	310 405	319 368	325 794	331 694	336 344	350 017	354 755	360 138	365 757	370 510	44.0
1. Energy industries	143 097	143 097	146 375	149 726	151 517	152 438	158 304	163 006	169 632	182 224	189 582	192 610	199 883	201 299	211 795	212 399	214 784	218 980	221 844	55.0
2. Manufacturing industries and construction	36 280	36 280	35 810	35 395	35 860	36 659	37 609	37 728	37 881	37 759	38 522	39 381	38 556	39 974	40 637	41 755	45 274	47 347	48 661	34.1
3. Transport	62 092	62 092	61 463	62 641	63 921	65 528	68 229	70 588	71 958	72 049	72 851	74 905	73 540	75 256	75 828	79 793	79 003	78 643	78 774	26.9
4. Other sectors	14 744	14 744	14 884	15 300	15 762	15 669	16 318	16 680	16 931	17 077	17 206	17 650	18 451	18 585	20 529	19 539	19 697	19 414	19 672	33.4
5. Other	1 012	1 012	996	1 046	1 073	1 123	1 255	1 369	1403	1 296	1 208	1 248	1 263	1 229	1 228	1 269	1 380	1 374	1 559	54.0
B. Fugitive emissions from fuels	29 207	29 207	28 775	30 429	30 793	29 755	31 080	29 331	31 172	32 458	30 349	32 829	33 430	32 296	31 618	32 285	32 692	34 347	37 653	28.9
1. Solid fuels	16 230	16 230	16 741	17 822	19 058	18 159	18 132	17 383	19 148	20 389	18 938	20 220	20 245	19 937	20 351	21 393	22 163	23 720	26 832	65.3
2. Oil and natural gas	12 978	12 978	12 034	12 606	11 735	11 596	12 948	11 948	12 024	12 069	11 411	12 609	13 185	12 360	11 267	10 892	10 529	10 627	10 821	–16.6
2. Industrial processes	**24 141**	**24 141**	**23 411**	**24 040**	**23 882**	**24 070**	**24 269**	**24 080**	**24 165**	**25 443**	**25691**	**25 731**	**26 381**	**26 831**	**27 937**	**29 019**	**27 793**	**29 387**	**30 343**	**25.7**
A. Mineral products	5 123	5 123	4 810	4 606	4 815	5 567	5 371	5 437	5 376	5 809	5 706	5 526	5 472	5 490	5 641	5 593	5 641	5 849	5 867	14.5
B. Chemical industry	416	416	406	503	600	561	660	687	695	776	793	911	1 035	963	979	986	1 065	1 313	1 326	218.8
C. Metal production	15 070	15 070	14 832	15 376	14 158	14 154	13 856	13 953	13 42	14 052	14 173	13 753	13 555	13 400	13 137	13 674	11 836	10 913	11 124	–26.2
D. Other production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA
E. Production of halocarbons and SF_6	1 126	1 126	1 126	1 054	1 447	812	719	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA
F. Consumption of halocarbons and SF_6	521	521	521	521	521	522	1 131	1 319	1 564	1 858	2 176	2 566	2 983	3 406	3 862	4 229	4 622	5 292	5 639	982.2
G. Other	1 885	1 885	1 716	1 980	2 341	2 455	2 532	2 683	2 789	2948	2 842	2 974	3 336	3 572	4 318	4 536	4 629	6 019	6 388	238.8
3. Solvent and other product use	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4. Agriculture	**86 832**	**86 832**	**87 001**	**85 329**	**84 846**	**85 375**	**86 333**	**86 628**	**87 848**	**88 049**	**91226**	**94 677**	**98 236**	**95 646**	**91 230**	**91 287**	**89 571**	**90 798**	**88 106**	**1.5**
A. Enteric fermentation	63 881	63 881	64 018	62 739	61 355	59 894	59 387	59 135	59 568	59 502	60 160	60 435	60 847	59 551	59 587	60 033	60 339	59 291	57 561	–9.9
B. Manure management	2 064	2 064	2 123	2 239	2 394	2 531	2 626	2 647	2 823	2 985	3 191	3 297	3 358	3 386	3 384	3 438	3 548	3 593	3 453	67.3
C. Rice cultivation	490	490	524	540	602	606	649	705	723	725	671	741	738	589	399	237	341	265	196	–60.0
D. Agricultural soils	13 496	13 496	13 590	13 443	13 589	13 619	13 965	14 261	14 829	15 152	15 824	16 592	17 098	16 598	16 234	16 226	16 285	15 828	15 002	11.2

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (Gg)	1990 (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	1995 (Gg)	1996 (Gg)	1997 (Gg)	1998 (Gg)	1999 (Gg)	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)	2005 (Gg)	2006 (Gg)	2007 (Gg)	Change from base to latest reported year %
E. Prescribed burning of savannas	6 608	6 608	6 460	6 075	6 590	8 414	9 382	9 533	9 515	9 280	10 977	13 202	15 772	15 165	11 262	11 018	8 650	11 481	11 585	75.3
F. Field burning of agricultural residues	292	292	286	293	315	311	324	347	390	405	403	410	422	357	365	335	407	339	309	5.8
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land use, land use change and forestry	**37 580**	**37 580**	**133 227**	**60 564**	**–2 560**	**–43 356**	**101 010**	**–15 261**	**–56 971**	**129 939**	**–46 013**	**–90 463**	**–78 658**	**283 885**	**114 112**	**–193 623**	**71 603**	**16 588**	**284 710**	**657.6**
A. Cropland	–256	–256	3 423	10 536	–4 360	–14 322	208	5 189	–5 644	19 746	2 682	–12 366	–12 932	58 596	–23 250	–27 264	–43 705	20 440	23 565	–9 318.5
B. Forest land	–47 343	–47 343	16 689	–36 646	–86 380	–74 988	–77 564	–70 937	–65 368	–61 878	–77 432	–62 400	–87 480	–6 526	115 298	–131 557	–95 720	–104 686	–18 916	–60.0
C. Grassland	89 088	89 088	116 586	90 116	91 851	49 649	182 217	53 847	17 248	175 314	31 739	–12 655	24 847	234 993	25 174	–31 322	214 015	103 868	282 703	217.3
D. Other	–3 910	–3 910	–3 472	–3 442	–3 671	–3 695	–3 851	–3 360	–3 208	–3 244	–3 002	–3 041	–3 093	–3 177	–3 109	–3 481	–2 986	–3 034	–2 643	–32.4
6. Waste	**18 807**	**18 807**	**18 787**	**18 580**	**18 508**	**17 999**	**18 040**	**16 650**	**16 441**	**15 799**	**15 959**	**15 824**	**15 996**	**16 072**	**15 126**	**14 740**	**14 441**	**14 182**	**14 567**	**–22.5**
A. Solid waste disposal on land	14 909	14 909	14 887	14 704	14 669	14 183	14 288	13 098	12 976	12 390	12 581	12 469	12 497	12 604	11 738	11 316	11 110	10 892	11 106	–25.5
B. Waste-water handling	3 813	3 813	3 815	3 791	3 753	3 730	3 660	3 486	3 437	3 381	3 349	3 327	3 472	3 441	3 360	3 395	3 303	3 261	3 432	–10.0
C. Waste incineration	85	85	85	85	85	86	91	66	28	28	29	28	28	28	28	28	28	29	29	–66.1
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. 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	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2 emissions including net CO_2 from LUCF	**453 794**	**453 794**	**550 728**	**483 049**	**423 603**	**385 260**	**542 447**	**430 800**	**400 461**	**602 093**	**436 580**	**404 392**	**427 079**	**791 075**	**630 040**	**328 461**	**596 239**	**551 058**	**825 888**	**82.0**
Total CO_2 emissions excluding net CO_2 from LUCF	**416 214**	416 214	417 500	422 485	426 163	428 616	441 437	446 061	457 432	472 154	**482 592**	**494 855**	**505 738**	**507 190**	**515 928**	**522 085**	**524 635**	**534 471**	**541 179**	**30.0**
Memo items:																				
International bunkers	**6 457**	6 457	6 433	6 642	7 046	7 427	8 609	9 109	9 137	9 530	9 801	10 187	10 483	9 615	8 766	8 852	9 556	10 775	11 994	85.8
Aviation	4 380	4 380	4 556	4 834	5 241	5 393	5 905	6 362	6 592	7 291	7 326	7 390	7 856	6 748	5 971	6 034	6 901	8 125	9 348	113.4
Marine	2 077	2 077	1 877	1 808	1 805	2 034	2 704	2 746	2 545	2 239	2 475	2 797	2 627	2 867	2 795	2 818	2 655	2 650	2 646	27.4
Multilateral operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NA**
CO_2 Emissions from biomass	**14 976**	**14 976**	**14 858**	**13 574**	**15 206**	**16 142**	**16 918**	**17 931**	**18 785**	**19 083**	**18 827**	**19 008**	**18 209**	**16 343**	**17 120**	**17 469**	**16 976**	**17 037**	**18 050**	**20.5**

Table AI.3 ***Trends in greenhouse gas emissions (Gg CO_2-e) by gas in Australia, 1990 to 2007***

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	CO_2-e (Gg)																	
CO_2 emissions including net CO_2 from LULUCF	308 287	405 376	338 900	281 549	246 012	401 070	292 482	258 697	459 034	293 220	255 157	272 375	635 593	479 953	177 764	449 137	401 146	674 932
CO_2 emissions excluding net CO_2 from LULUCF	277 815	279 055	284 401	288 854	293 666	304 310	311 918	320 094	333 455	343 236	349 837	355 990	360 370	373 882	378 949	382 663	390 609	396 280
CH_4 emissions including CH_4 from LULUCF	119 799	119 726	118 834	117 291	115 504	116 768	113 896	116 515	116 464	115 685	119 261	122 513	122 658	118 295	118 614	115 581	118 200	119 774
CH_4 emissions excluding CH_4 from LULUCF	114 699	114 573	114 405	113 857	112 375	113 768	110 963	113 326	113 540	112 880	116 356	118 864	116 154	112 367	112 931	111 891	113 676	115 290
N_2O emissions including N_2O from LULUCF	20 110	20 025	19 793	19 952	20 555	21 447	21 884	22 626	23 310	24 518	26 302	27 664	27 937	26 486	26 385	25 362	25 831	25 042
N_2O emissions excluding N_2O from LULUCF	18 102	18 272	18 157	18 641	19 386	20 196	20 642	21 389	21 874	23 319	24 990	26 355	25 778	24 374	24 507	23 923	24 306	23 468
HFCs	1 126	1 126	1 054	1 447	813	1 329	798	1 043	1 337	1 655	2 045	2 462	2 885	3 341	3 708	4 101	4 771	5 118
PFCs	3 950	3 953	3 947	2 843	1 856	1 313	1 209	1 053	1 424	977	1 104	1 545	1 481	1 444	1 469	1 536	589	502
SF_6	521	521	521	521	521	521	530	527	525	525	523	521	521	521	521	521	521	521
Total (including LULUCF)	**453 794**	**550 728**	**483 049**	**423 603**	**385 260**	**542 447**	**430 800**	**400 461**	**602 093**	**436 580**	**404 392**	**427 079**	**791 075**	**630 040**	**328 461**	**596 239**	**551 058**	**825 888**
Total (excluding LULUCF)	**416 214**	**417 500**	**422 485**	**426 163**	**428 616**	**441 437**	**446 061**	**457 432**	**472 154**	**482 592**	**494 855**	**505 738**	**507 190**	**515 928**	**522 085**	**524 635**	**534 471**	**541 179**

Table AI.4 ***Trends in greenhouse gas emissions (Gg CO_2-e) by sector in Australia, 1990 to 2007***

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	CO_2-e (Gg)																	
1. Energy	286 433	288 302	294 537	298 927	301 173	312 795	318 703	328 978	342 864	349 717	358 623	365 124	368 640	381 635	387 040	392 830	400 104	408 163
2. Industrial processes	24 141	23 411	24 040	23 882	24 070	24 269	24 080	24 165	25 443	25 691	25 731	26 381	26 831	27 937	29 019	27 793	29 387	30 343
3. Solvent and other product use	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO	IE,NA, NO
4. Agriculture	86 832	87 001	85 329	84 846	85 375	86 333	86 628	87 848	88 049	91 226	94 677	98 236	95 646	91 230	91 287	89 571	90 798	88 106
5. Land use, land-use change and forestry	37 580	133 227	60 564	–2 560	–43 356	101 010	–15 261	–56 971	129 939	–46 013	–90 463	–78 658	283 885	114 112	–193 623	71 603	16 588	284 710
6. Waste	18 807	18 787	18 580	18 508	17 999	18 040	16 650	16 441	15 799	15 959	15 824	15 996	16 072	15 126	14 740	14 441	14 182	14 567
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)	**453 794**	**550 728**	**483 049**	**423 603**	**385 260**	**542 447**	**430 800**	**400 461**	**602 093**	**436 580**	**404 392**	**427 079**	**791 075**	**630 040**	**328 461**	**596 239**	**551 058**	**825 888**

Annex II Summary of reporting of supplementary information under Article 7, Paragraph 2, of the Kyoto Protocol in Australia's Fifth National Communication on Climate Change

National Systems (i.e. emissions inventories) (under Article 5, Paragraph 1,2); and National Registry Information	Relevant part of Australia's Fifth National on Climate Change
Contact details of organisation with responsibility for the National Greenhouse Gas Inventory.	Chapter 3
Roles, responsibilities and institutional arrangements under the National Greenhouse Gas Inventory.	Chapter 3
Process/results of key source identification.	Chapter 3
Process to reassess previously submitted data.	Chapter 3
Description of quality assurance/quality control plans, review procedures (internal/external).	Chapter 3
Description of process for approval of the National Greenhouse Gas Inventory.	Chapter 3
Methodology of the National Greenhouse Gas Inventory.	Chapter 3
Information on Australia's National Registry.	Chapter 3

Mechanisms related to Articles 6,12, and 17 (Joint Implementation, Clean Development Mechanism, and Emissions Trading respectively)	Reported
Details of how the use of such mechanisms is supplementary to domestic action.	Chapter 5

Policies and Measures (related to Article 2)	Reported
Reporting of all policies and measures linked to emissions reduction, including co-operation with other Parties.	Chapter 4
Steps taken to implement decisions by International Civil Aviation Organization and International Maritime Organization to reduce emissions from aviation/marine bunker fuels not controlled by the Montreal Protocol.	Chapter 3; Chapter 4
Information on implementation of policies and measures.	Chapter 4

Legislative arrangements and enforcement and administrative procedures	Reported
Description of regional/domestic legislative arrangements and enforcement and administrative procedures Australia has to meet its commitments under the Kyoto Protocol. Legal authority for such programmes, for example procedures for non-compliance.	Chapter 3; Chapter 4
Provision to make information on above procedures publicly accessible.	Chapter 3; Chapter 4
Description of institutional arrangements and decision making procedures in place to coordinate activities under Articles 6, 12 and 17.	Chapter 4; Chapter 5
Description of legislative/administration procedures for implementation of land use, land-use change, and forestry activities, and also any elected activities under these that contribute to conservation of biodiversity, and sustainable use of natural resources.	Chapter 4; Chapter 6

Financial resources and transfer of technology including information under the Kyoto Protocol (under Articles 10 and 11)	Reported
Assistance to developing country Parties that are particularly vulnerable to climate change.	Chapter 6; Chapter 7
Provision of new and additional resources.	Chapter 7
Provision of financial resources.	Chapter 7
Activities related to transfer of technology.	Chapter 7

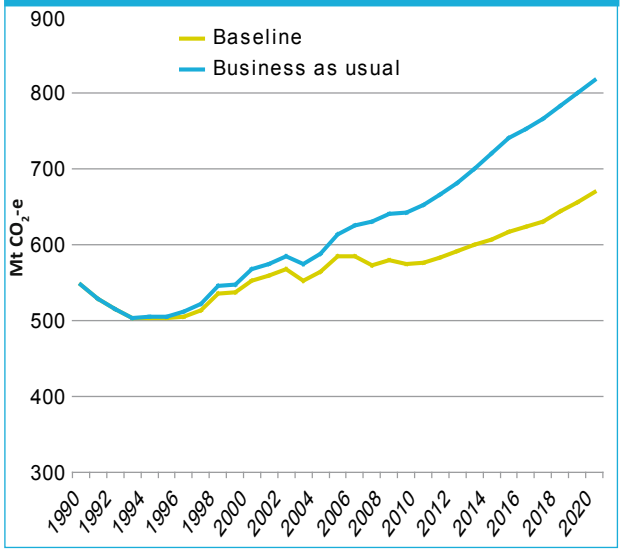
Annex III Summary of 2008–12 projections under Kyoto accounting rules

Australia is on track to achieve its target of limiting greenhouse emissions to 108% of 1990 emissions over the period 2008–12 under Kyoto accounting rules.

According to Kyoto accounting rules, Australia's greenhouse gas emissions are projected to reach around 106% of 1990 levels over the Kyoto period or 581 Mt CO_2-e. Emissions from 1990 to 2020 including and excluding savings from greenhouse measures are shown in Figure AIII.

A summary of the sectoral breakdown of the current projection using Kyoto accounting rules is shown in Table AIII.

***Figure AIII** Baseline emissions estimate (Mt CO_2-e), 1990 to 2020 (Kyoto accounting method)*



Emissions in 2020 are projected to reach 121% of the 1990 level on an indicative basis, reflecting the impact of ongoing growth in emissions in the energy sector.

***Table AIII** Baseline greenhouse gas emissions projections (Mt CO_2-e) 1990, 2010 and 2020 (Kyoto accounting method)*

	1990	2000	2010[a]	2020
Energy	286	359	419	464
Stationary energy	195	251	293	322
Transport	62	75	81	95
Fugitive emissions from fuels	29	33	39	61
Industrial processes	24	26	33	38
Agriculture	87	95	88	97
Waste	19	16	15	15
Land-use change	132	73	49	49
Forestry	–	–15	–21	–7
Total	548	553	577	669

Note: These projections are made under Kyoto Protocol accounting rules, which differ from those of the United Nations Framework Convention on Climate Change, notably in their treatment of forestry sinks.

a The 2010 emissions projection is representative of the 2008 to 2012 average.

b Forestry sinks estimates relate to sequestration in Kyoto-compliant plantations.

Annex IV Atmospheric essential climate variables

The primary collector of atmospheric essential climate variables (ECVs) is the Bureau of Meteorology. Data responding to the specific requirements in the UNFCCC reporting guidelines is presented in tables AIV.1 to AIV.3.

Table AIV.1 National contributions to the surface-based atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	68	68	68	68	68
	Precipitation	67	67	67	67	67
Full World Weather Watch/ Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour	8551	855	855	855	855
	Precipitation	7831	783	783	783	783
Baseline Surface Radiation Network (BSRN)	Surface radiation	3	3	3	3	12
Solar radiation and radiation balance data	Surface radiation	9	83	8	9	16
Ocean drifting buoys	Air temperature, air pressure	27	27	30	27	Unknown
Moored buoys	Air temperature, air pressure	0	0	0	0	0
Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour	11	11	20	20	~17
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure	164	16	16	16	16
	Precipitation	64	6	6	6	6

1 Includes Australian Antarctic stations, but excludes small isolated islands.

2 Alice Springs is the only complete BSRN archive. Darwin and Cocos Island have only partial records (from 2005 to present)

3 Cape Grim does not adhere to GCMP.

4 Isolated islands located off the continental shelf, including Christmas, Cocos, Lord Howe, Norfolk, Macquarie and outer Coral Sea Automated Weather System.

Table AIV.2 ***National contributions to the upper-air atmospheric essential climate variables***

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Upper Air Network (GUAN)	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour	16	16	16	16	16
Full WWW/GOS Upper Air Network	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour	38	38	38	38	38

Table AIV.3 ***National contributions to the atmospheric composition***

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
World Meteorological Organization/ Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO2 & CH4 Monitoring Network	Carbon dioxide	1	1	1	1	1
	Methane	1	1	1	1	1
	Other greenhouse gases	1	1	1	1	1
WMO/GAW ozone sonde networka	Ozone	3	3	4	3	3
WMO/GAW column ozone networkb	Ozone	5	5	5	5	5
WMO/GAW Aerosol Networkc	Aerosol optical depth	9	9	8	3	17
	Other aerosol properties	1	1	1	1	1

Responses to specific points on atmospheric ECVs

(a) Applying the GCMPs to all surface climate networks (A3)

A national policy is in place which directs that changes to the network follow the GCMP where possible. This includes station overlaps, field testing, metadata and comparison of new systems. However, there are exceptional cases beyond the Bureau's control where the principles cannot be satisfied (e.g. where a building development surrounding an observation site makes comparisons impossible).

(b) Incorporating atmospheric pressure sensors into drifting buoy programs (A5)

All drifting buoys purchased by the Bureau incorporate, as standard, barometric pressure sensors. The Bureau also participates in the DBCP Barometer Upgrade Program, whereby a standard SST barometer purchased by the NOAA/AOML Global Drifter Program is fitted with a barometric pressure sensor payed for by the Bureau.

(c) Ensuring availability of three-hourly mean sea level pressure and wind speed and direction data from GSN stations (A10)

At most GSN surface sites, automated observations are reported at least hourly. These observations of pressure and wind are coded to hourly SYNOPs which satisfy the requirement for reporting at WMO standard hours. Several existing stations (approximately 10) were configured to report SYNOPs at WMO standard hours.

(d) Implementing a reference network of high-altitude, high-quality radiosondes (A16)

The Bureau is monitoring international developments with a view to implementing an Australian contribution to the GRUAN network.

(e) Operating the WWW/GOS radiosonde network in full compliance with the GCMPs and coding conventions (A17)

The Bureau is committed to supporting GCOS GCMPs in its radiosonde network. Over the past decade it has improved its ability to record and report metadata changes to upper-air systems. The Bureau provides ongoing support to the Australian GUAN stations. Data homogeneity has been improved by the introduction of more robust communications systems and automated systems.

(f) Submitting metadata records and inter-comparisons for radiosonde observations to the specified international data centres (A18)

These data are archived within the Bureau and are available on request. However, they have not been routinely forwarded to international data centres as a matter of course.

(g) Developing a network of ground-based Global Positional System (GPS) receivers for measuring water vapour (A21)

The Bureau is currently trialling GPS data from a real-time regional network. These data are being trialled in NWP assimilation, and total precipitable water (TPW) data are being compared against radiosonde data. Preliminary results are expected by mid-2009.

In collaboration with Geoscience Australia, the Bureau will obtain real-time ZTD and TPW data from a planned national network of 200 stations to be operated by Geoscience Australia. More accurate archival data will also be available using post-processed orbit information. Currently, this archive is available for up to 10 years from a small number of existing stations.

Oceanic essential climate variables

Table AIV.4 ***National contributions to the oceanic essential climate variables—surface***

Contributing Networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global surface drifting buoy array on 5x5 degree resolution	Sea surface temperature, sea level pressure, position-change-based current	27	27	35	27	Unknown
GLOSS Core Sea-level Network	Sea level	28	28	40	34	34
Voluntary observing ships (VOS)	All feasible surface ECVs	80	80	100	80	Unknown
Ship of Opportunity Programme	All feasible surface ECVs	13	13	13	13	~85

Table AIV.5 ***National contributions to the oceanic essential climate variables – water column***

Contributing Networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global reference mooring network	All feasible surface and subsurface ECVs	3	3	8	0	0
Global tropical moored buoy network	All feasible surface and subsurface ECVs	0	0	0	0	0
Argo network	Temperature, salinity, current	225	225	250	225	268 (273 deployed, 5 failed on deployment)
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biogeochemistry variables	1 in 2009; next one planned for 2013	1	1	1	1

Responses to specific points on oceanic ECVs

(a) Improving metadata acquisition and data management for the VOSClim subset of the Voluntary Observing Ships (VOS) (O6)

The complete suite of Pub47 metadata, including photos, is collected from all VOSClim ships recruited by Australia.

(b) Ensuring that high-frequency (hourly or less) sea level observations are available for all coastal tide gauges, including historical records, are corrected for sea level pressure and are submitted to the specified international data centres (O13)

All Australian sea-level data are available at high frequency for coastal tide gauges including historical data. Twenty-six of the GLOSS core network of coastal tide gauges operated by the Bureau have collocated barometric pressure sensors.

All sea-level data collected by the Bureau are made available to international data centres. Some of the Australian data are not collected or at least processed by the Bureau and these data do not, as yet reach international data centres.

(c) Including sea level objectives in the capacity-building programs of GOOS, JCOMM, WMO, other related bodies and the system-improvement programme of GCOS (O14)

The Bureau has recently hosted three scientists from developing countries for training programs and to develop their sea-level monitoring networks. One of the scientists, in particular, plans to use the skills that he gained to develop training programs in his own country (India) for his 38 staff members.

In addition, a component of the South Pacific Sea-level and Climate Monitoring Project was aimed specifically at capacity building.

(d) Developing a robust program to observe sea surface salinity, to include VOS ships, research ships, reference moorings and drifting buoys (O15)

IMOS is increasing the coverage of sea-surface salinity measurements with thermosalinographs installed on the Australian Institute of Marine Science research vessels Cape Ferguson and Solander, and the Heron Island ferry. These will build on the existing measurements from the marine national facility, the RV Southern Surveyor, and vessels Aurora Australis, Southern Surveyor and L'Astrolabe, providing coverage of the oceans surrounding Australia including the western Coral Sea, Tasman Sea, Southern Ocean and eastern Indian Ocean.

IMOS is also establishing a network of 10 near-shore National Reference Stations, eight of which have continuous salinity sensors at the surface and 10 metres off the bottom. Water samples for sea-surface salinity and biogeochemical parameters will be taken at least bi-monthly if not monthly. The stations with moorings are located at Maria Island (TAS), Kangaroo Island (SA), Esperance (WA), Rottnest Island (WA), Yongala (QLD) and Port Hacking (NSW); Dampier (WA), Darwin (NT) and Stradbroke Island (QLD) will soon be deployed. The Great Barrier Reef Ocean Observing System will most likely include continuous measurements of sea-surface salinity on two additional moorings (Heron Island and Lizard Island). The Southern Ocean Time Series mooring will also measure sea-surface salinity at 47°south, 140°east.

Since mid-2008 the spatial coverage, timeliness and quality of sea surface temperature (SST) observations from research and volunteer observing ships have been significantly enhanced over the Australian region. Through IMOS six new ship SST data streams are now available to the GTS. Whereas SST observations from VOS obtained by bucket samples and engine intake sensors typically have a random error of 1.3 K, the new IMOS ship SST observations from hull-contact sensors and calibrated thermistors consistently have RMS errors of approximately 0.3 K (comparable to that obtained from drifting buoys).

(e) Implementing a program for measuring surface pCO_2 (O17)

The IMOS-funded upgrade of the research vessels *Southern Surveyor* and *l'Astrolabe* will include sensors to measure pCO_2 uptake in critical areas. The *Southern Surveyor* voyage schedule includes planned lines in the Coral and Tasman seas and the Southern and Pacific oceans, while *l'Astrolabe* takes a repeat section from Hobart, Tasmania to Dumont D'Urville, Antarctica. Both these vessels will deliver data in real time. The 10 National Reference Stations (see d above) will measure dissolved inorganic carbon (DIC), alkalinity (ALK), salinity, Ph – DIC ratio, and dissolved oxygen (at selected stations only). In the next year, two stations will be enhanced with automated pCO_2 moorings (Maria Island and Yongala); if successful, this technology may be rolled out to other stations.

(f) Implementing a wave measurement component as part of the Surface Reference Mooring Network (O19)

The Bureau operates two Waverider buoys, and routinely receives wave data from another 27 platforms, mostly Waverider buoys, around the coast of Australia. The data are mostly on the GTS.

(g) Improving in situ sea ice observations from buoys, visual surveys (Ship of Opportunity Programme (SOOP) and aircraft) and upward-looking sonars, and implementing observations in the Arctic and Antarctic (O23)

No Bureau-owned buoys are capable of sea-ice observations. Very few Australian-recruited VOS travel in ice-prone areas; however, it is expected they would submit an ice observation in the BBXX as necessary.

(h) Conducting the systematic global full-depth water column sampling of 30 sections repeated every 10 years (including ocean carbon inventory change) (O25)

Australia carries out one full-depth section of the repeat World Hydrographic Program approximately every three years. SR3 was occupied in 2007 and PR15 before 2009.

(i) Performing the 41 SOOP XBT/XCTD trans-oceanic sections (O26)

The Bureau samples in FRX mode on five trans-ocean sections. CSIRO samples in HDX mode on three trans-ocean sections.

(j) Developing capability for systematic measurement of biogeochemical and ecological ECVs (O30)

IMOS will measure biogeochemical ECVs on ships in the Tasman Sea and the Southern Ocean. Biogeochemical sensors have been added to the research ship, RV Southern Surveyor, to provide spatial coverage all around Australia. Continuous plankton recorder devices have been installed on two lines: one line runs down the core of the East Australian Current, and the second is installed on the L'Astrolabe crossing the Southern Ocean to Antarctica.

IMOS also collects biogeochemical and ecological samples from the National Reference Stations at least bimonthly.

(k) Supporting data rescue projects and implementing regional, specialized and global data and analysis centres (O36 and O37)

Under a project funded by the Department of Climate Change, the National Climate Centre digitised 286 logbooks from 86 voluntary observing ships, primarily from the 1970s and 1980s, and archived the data in the national database. The digitisation project will be extended to earlier periods as additional resources become available.

A separate project is under way to incorporate Australian and south-west Pacific sea-level data into the Australian climate databank, and to develop and deliver sea-level climate products based on these data. Activities include (i) transferring existing National Tidal Centre data to the climate databank; (ii) auditing available historical data and metadata, developing software and digitising relevant analogue sea-level data; and (iii) developing various products based on these datasets, and delivering them to users through an appropriate web interface.

(l) Developing plans and pilot projects for the production of global products based on data assimilation into models for all possible ECVs, including undertaking pilot projects of reanalysis of ocean data (O24, O41 and O40)

Under the BLUElink Project (Bureau of Meteorology, CSIRO and Royal Australian Navy), ocean data are assimilated operationally into an ocean analysis/forecast model, with operational products delivered to users via the Bureau's external website. The model is global, though with eddy-resolving resolution only in the Australian region. Data currently assimilated include SST, sea surface topography and sub-surface temperature and salinity. The next version of the model, now under development, will include some tidal interactions and river runoff input data. Reanalysis/hindcast products are also available from the BLUElink Reanalysis (BRAN) component of the project, through CSIRO.

Terrestrial essential climate variables

Table *AIV*.6 National contributions to the terrestrial domain essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS baseline river discharge network (GTN-R)	River discharge	15[1]	Unknown	15	15	20
GCOS Baseline Lake Level/ Area/ Temperature Network (GTN-L)	Lake level/area/ temperature	0[2]	0	0	0	0
WWW/GOS synoptic network	Snow cover	20	20	20	0	0
GCOS glacier monitoring network (GTN-G)	Glaciers mass balance and length, also ice sheet mass balance	10[3]	10	10	10	21
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole-temperatures and active-layer thickness	0[4]	0	0	0	0

1 As a result of the introduction of the *Water Act 2007* by the Australian Government, the Bureau of Meteorology is responsible, inter alia, for providing access to Australia's water information. The Bureau is therefore in a position both to review the appropriateness of the GTN-R network and to provide updates of data and metadata for the stations selected to make up the GTN-R network. This may be a worthwhile exercise to be conducted in conjunction with the GCOS secretariat.

2 The lakes listed in the GTN-L network do not make a great deal of sense. The five lakes (Amadeus, Eyre, Frome, Gairdner and Torrens) are all salt lakes. Lake Eyre filled only three times last century and Lake Torrens only once. Consequently there will be no lake-level monitoring stations associated with these lakes. As per footnote 1, it may be useful for the Bureau to re-assess the list of Australian lakes in the GTN-L network.

3 Many of the AWS (our GTN-G network) were installed with sonic transducers to measure the change in surface height with respect to the station mast as a result of accumulation of snow. But only 10 of these have successfully returned observations and those were for various time periods—some for months and some for years. The Bureau does not have continuous snow accumulation records. All of these sensors have since failed. But good long-term average observations of snow accumulation rate can be gained by analysis of when sensors at various heights on the masts are buried by the rising snow surface. This can be done for all stations, and there are 20 sites, most distributed widely across the surface of the ice sheet. There was an additional station operating for some months on a glacier on Heard Island with a sonic transducer. There are 10 stations currently returning data (air temperature, snow temperature, pressure, wind, etc) via Systeme ARGOS, and it is from these data that the Bureau derives the long-term average.

4 The Bureau has assumed that permafrost means frozen ground (i.e. frozen soil or rock). By this definition Australia has no stations. If 'ground' includes permanent snow/ice cover, then the Bureau does have numbers it can contribute to GTN-P.

Responses to specific points on terrestrial ECVs

(a) Developing a global network of approximately 30 sites based on a progressive evolution of existing reference sites to monitor key biomes and provide the observations required for the calibration and validation of satellite data (T3)

The global FluxNet network of flux tower sites (daac.ornl.gov/FLUXNET) now includes more than 150 sites worldwide, of which a large subset are being used for calibration/validation of satellite data (e.g. through the widespread provision of MODIS data cutouts for individual sites). Australia is an active participant in this program through the Ozflux network (www.cmar.csiro.au/ozflux/index), which includes seven sites of which two (Tumbarumba and Howard Springs) provide long (~10-year) records. The Tumbarumba record in particular has been the basis for many satellite calibration/validation activities on terrestrial products including LAI, NPP and others.

(b) Maintaining and expanding programs for monitoring groundwater and aquifers

Through the Australian Government's new 'Water for the Future' plan and under the *Water Act 2007*, the Bureau of Meteorology has been given an expanded role in water information. This role includes the analysis of groundwater information as an essential component of the water balance and water use in Australia. The Water for the Future plan is supported by a five-year, $80 million funding program (the Modernisation and Extension of Hydrologic Monitoring Systems Program) administered by the Bureau, which is now in its third year. This funding program aims to improve the collection, management and sharing of water information across Australia. A number of projects related to the collection of groundwater data of improved accuracy, currency and coverage have been funded in the first three rounds. As the Bureau further develops its role in water information, additional opportunities for improvements to monitoring will undoubtedly evolve.

(c) Archiving and disseminating information related to irrigation and water resources (T9)

As part of its new role (see b above), the Bureau of Meteorology will be required to complete, on an annual basis, National Water Resources Assessments and National Water Accounts. Both of these products will require access to information on irrigation and water resources and the Bureau will have the role of archiving and disseminating this information. The Bureau is currently undertaking pilot water resources assessments and water accounts that address, inter alia, rural scenarios (including irrigation).

To deliver water information to users, the Bureau will develop and maintain the Australian Water Resource Information System (AWRIS), an online information tool that will be freely accessible to the public. Currently in development, AWRIS will integrate and add value to extensive measurements of river flows, groundwater levels, reservoir storage volumes, water quality, water use, water entitlements and water trades. AWRIS will be the authoritative repository for water data and reporting in Australia. These developments will provide Australia with an opportunity to review its contributions to global networks and will enable improved access to the associated data.

(d) Strengthening existing sites for observing snow cover and snowfall and recovering and submitting historical data to the specified international data centres (T10)

Training has been provided to volunteer observers in areas that may experience snow to report snow cover. There has been no progress with submitting historical data to the international data centres.

(e) Maintaining sites for observing glaciers and adding additional sites and infrastructure in Africa, the Himalayas, New Zealand and South America (T13)

Not applicable.

(f) Adding the 150 additional permafrost sites identified by GTN-P to cover the high mountains of Asia, Europe and the southern hemisphere, and the North American alpine lands and lowlands, and providing data to the specified international data centres (T16)

Not applicable.

(g) Reanalysing historical data concerning the terrestrial ECVs

Extensive reanalysis of historic data (1900 to present and ongoing) is occurring through the Australian Water Availability Project. This project not only re-analyses and grids meteorological drivers (precipitation, daily maximum and minimum temperatures, solar radiation), but also calculates full terrestrial water balance (stores and fluxes) and successfully compares predictions (especially runoff) with data from 200 unimpaired gauged catchments across Australia.

Abbreviations and acronyms

AAU	assigned amount unit
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACCESS	Australian Community Climate and Earth-System Simulator
ACCSP	Australian Climate Change Science Program
ACIAR	Australian Centre for International Agricultural Research
AGEIS	Australian Greenhouse Emissions Information System
ANREU	Australian National Registry of Emissions Units
APPEA	Australian Petroleum Production & Exploration Association
AusAID	Australian Agency for International Development
AuSSI	Australian Sustainable Schools Initiative
AVHRR	Advanced Very High Resolution Radiometer
BoM	Bureau of Meteorology
BRS	Bureau of Rural Sciences
CRC	Cooperative Research Centre
CCRP	Climate Change Research Program
CIE	Centre for International Economics
COAG	Council of Australian Governments
CPRS	Carbon Pollution Reduction Scheme
CRF	Common Reporting Format (UNFCCC)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCC	Australian Government Department of Climate Change
DEWHA	Australian Government Department of Environment, Water, Heritage and the Arts
DRET	Australian Government Department of Resources, Energy and Tourism
ENSO	El Niño – Southern Oscillation
ESAA	Energy Supply Association of Australia
GCCSI	Global Carbon Capture and Storage Institute
GCS	Global Communities for Sustainability
GDP	gross domestic product
GEF	Global Environment Facility
GPS	global positioning system
HFCs	hydrofluorocarbons
ICCAI	International Climate Change Adaptation Initiative
IMOS	Integrated Marine Observing System
IPCC	Intergovernmental Panel on Climate Change
LNG	liquefied natural gas

LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
NCAS	National Carbon Accounting System
NCCARF	National Climate Change Adaptation Research Facility
NCOS	National Carbon Offset Standard
NFI	National Forest Inventory
NGERS	National Greenhouse and Energy Reporting System
NGO	non-government organisation
NHMS	national meteorological and hydrological service
NMVOCs	non-methane volatile organic compounds
PFCs	perfluorocarbons
QA/QC	quality assurance/quality control
QDME	Queensland Department of Mines and Energy
REDD	reducing emissions from deforestation and forest degradation in developing countries
RET	Renewable Energy Target
UNFCCC	United Nations Framework Convention on Climate Change
VET	vocational education and training

Units

CO_2-e	carbon dioxide equivalent
Gg	gigagram (equal to 1000 tonnes or 1 kilotonnes)
kt U	10^3t Uranium
Mt	million tonnes
MW	megawatt
PJ	petajoule
ppm	parts per million

Glossary

2020 target range An unconditional commitment to reduce emissions to 5% below 2000 levels by 2020. A commitment to reduce emissions to 15% below 2000 levels by 2020 if there is an agreement where major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's. A commitment to reduce emissions to 25% below 2000 levels by 2020 in the context of a comprehensive global agreement capable of stabilising atmospheric concentrations of greenhouse gases at 450 parts per million (ppm) CO_2-equivalent or lower.

abatement Refers to emissions reductions made beyond that which would have been achieved in the *business-as-usual* scenario. Also referred to as *beyond BAU abatement*.

abatement challenge The amount of additional abatement required to meet the 2020 target range.

accretion Growth of coastal shorelines by steady addition of sediments.

afforestation Under the Kyoto Protocol, afforestation is defined as the direct human-induced conversion to forested land of land that has not contained a forest for at least 50 years.

aragonite undersaturation Increasing carbon dioxide levels in the ocean are driving its chemistry towards a decrease in the carbonate ion needed to form aragonite (one mineral form of calcium carbonate). The consequent 'undersaturation' of aragonite may affect the ability some plankton to build and maintain shells.

banking of permits The ability of liable entities to use permits issued or created in one compliance period in a future compliance period under an emissions trading scheme.

baseline The level of emissions expected to occur in the absence of the CPRS, but including the impact of all other measures.

biosphere The biological component of earth systems, which includes all living organisms on earth, together with the dead organic matter produced by them.

business as usual Refers to a projection that incorporates changes in activity levels and greenhouse gas emission factors, but excludes any effects directly attributable to climate change mitigation policies and measures. Also referred to as *without measures*.

bathymetry The measurement and mapping of underwater depth of oceans or large bodies of water.

cap-and-trade scheme An emissions trading regime in which a limit (or cap) is placed on the total emissions allowable from the activities or sectors covered under the scheme. Tradeable emissions units are issued up to an amount equal to the cap.

carbon capture and storage Technology to capture and store greenhouse gas emissions from energy production or industrial processes. Captured greenhouse gases have the potential to be stored in a variety of geological sites.

carbon sink Natural or man-made systems that absorb and store carbon dioxide from the atmosphere, including trees, plants and the oceans.

commercial vehicles Refers to light commercial vehicles, heavy-duty and medium-duty trucks and buses.

covered sectors Sectors that are covered by the Carbon Pollution Reduction Scheme and attract an obligation to surrender a carbon pollution permit or eligible international unit.

CPRS scheme cap Determines the number of carbon pollution permits that will be issued by the Australian Government under the CPRS.

deforestation The conversion of forested land to an alternative, non-forest use.

domestic emissions Australia's emissions level before accounting for the purchase of international permits to help meet national emissions targets.

emissions The release of greenhouse gases into the atmosphere.

enteric fermentation Part of the digestive process of ruminant animals, such as cows and sheep, which results in the release of methane.

eutrophication The process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

extreme weather event An event that is rare at a particular place and time of year (IPCC). 'Rare' can be defined as being in the 10th or 90th percentile of the probability observed from past trends.

fire weather Fire weather is influenced by a number of factors, including fuels, terrain, land management, fire suppression and weather. The Forest Fire Danger Index is used as an indication of fire weather risk and is based on near-surface daily maximum temperature, daily total precipitation, 3 p.m. relative humidity and 3 p.m. wind speed.

greenhouse gases The atmospheric gases responsible for causing global warming and climate change. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Group of Eight (G8) A group of finance ministers and central bank governors from eight major economies. Collectively, the G8 is comprised of the wealthiest developed nations including Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

groyne A protective structure of stone or concrete that extends from the shore into the water to help prevent erosion.

Indian Ocean Dipole The see-sawing nature of sea-surface temperatures in the eastern and western Indian Ocean.

indirect emissions Indirect emissions are emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand of goods and services), but which are physically produced by the activities of another organisation. Examples include electricity production, 'upstream' emissions generated in the production of goods purchased or processed by the entity and 'downstream' emissions associated with transporting and disposing of products sold by the entity.

Kyoto period See *Kyoto Protocol—first commitment period.*

Kyoto period average Refers to the average of emissions over the five-year first commitment period of the Kyoto Protocol, from 2008 to 2012.

Kyoto Protocol—first commitment period Generally refers to the time frame in which Annex I countries are required to meet their emissions reduction obligations under the Kyoto Protocol. The Kyoto Protocol's first commitment period is from 2008 to 2012.

Kyoto target Australia's Kyoto target is 108% of 1990 levels on average over the period 2008–12.

light detection and ranging (LiDAR) system A technology that allows precise estimates of terrain and tree height to be obtained from aircraft. It involves firing a laser pulse at a target and measuring the return energy as a function of time.

mass–balance An application of conservation of mass (that is, matter cannot disappear or be created) to the analysis of physical systems. By accounting for material entering and leaving a system, mass flows can be identified that might have been unknown, or difficult to measure, without this technique.

measures Refers to past, current or committed Australian, state or territory, or local government policy actions that have an impact on greenhouse gas emissions, causing them to deviate from the business-as-usual path after the base year of 1990.

megadiverse The megadiverse countries are a group of countries that harbor the majority of the earth's species and are therefore considered extremely biodiverse. The World Conservation Monitoring Centre, an agency of the United Nations Environment Programme, has identified 17 megadiverse countries, most located in the tropics. Brazil, Indonesia, South Africa, Colombia and Australia harbour the most diversity.

Montreal Protocol The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in 1987. It controls the consumption and production of chemicals that destroy stratospheric ozone, such as chlorofluorocarbons.

national emissions Australia's emissions level after accounting for the purchase of international permits to help meet national emissions targets.

national emissions trajectory Broad guidance over the pathway of Australia's future national emissions.

National Greenhouse Gas Inventory An inventory of Australia's greenhouse gas emissions, prepared as part of Australia's National Greenhouse Accounts and used by the Australian Government to meet its international reporting obligations.

Niño 3.4 Sea Surface Temperature Average sea-surface temperature anomaly in the region bounded by 5°N to 5°S, from 170°W to 120°W. This region has large variability on El Niño timescales, and is close to the region where changes in local sea-surface temperature are important for shifting the large region of rainfall typically located in the far western Pacific.

shoreline recession Progressive landward shift of the average long-term position of the coastline.

Southern Oscillation Index Calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin.

temporal-residual-mean theory A practical way of representing the correct velocity at which heat and other tracers are included in ocean models.

thermal expansion In connection with sea level, the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence to sea-level rise.

thermohaline circulation The 'conveyor belt' that transports heat, nutrients and oxygen around the world's oceans.

three-way catalytic converters A device used to reduce the toxicity of emissions from an internal combustion engine.

uncovered sectors Sectors that are not covered by the Carbon Pollution Reduction Scheme.

with measures Refers to the 'best estimate' of future emissions levels, adopting the most likely assumptions and modelling parameters.