AUSTRALIA'S THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

A REPORT UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

2002

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CHAPTER ONE
EXECUTIVE SUMMARY

Australia's *Third National Communication* under the United Nations Framework Convention on Climate Change (UNFCCC) sets out progress on implementation of its international obligations since submitting its *Second National Communication* in November 1997.

Since the announcement of the Prime Minister's 1997 Safeguarding the Future package of measures reported in Australia's *Second National Communication*, significant progress has been made in implementing these and a range of other major policies and measures (including programs in 1999 under Measures for a Better Environment) to place Australia's greenhouse response efforts, proportionate to its size, at the forefront of global action. With the establishment of the Australian Greenhouse Office and adoption of a National Greenhouse Strategy, Australia has developed a comprehensive strategic framework of domestic greenhouse action that reflects its particular national circumstances and recognises Australia's vulnerability to climate change. The projections of Australia's future emissions profile assess the impact of these policies and measures on reducing Australia's emissions.

The *Third National Communication* also gives details of the likely impacts of climate change on Australia and the research and systematic observation that is being carried out in relation to climate, climate change and climate variability. It also outlines Australia's financial commitment to assisting developing countries respond and adapt to climate change and the steps Australia has taken in climate change education and public awareness raising.

The Commonwealth Government decided in July 2002 to commence development of a forward strategy on climate change that will position Australia for a longer term response to climate change. The Government also decided not to ratify the Kyoto Protocol unless and until it is demonstrated that it is in the national interest to do so. The longer term focus will however be combined with a shorter term focus upon development and investment of

funding in domestic programs to meet Australia's target under the Kyoto Protocol of limiting greenhouse emissions to 108% of 1990 emissions levels over the period 2008 – 2012. As part of the way forward, a government-business dialogue will take place to inform the development of Australia's forward greenhouse strategy. The Government will also work closely with States and Territories to ensure a coherent national approach.

NATIONAL CIRCUMSTANCES

Australia is the sixth largest country in the world (769 million hectares) and its population of just over 19 million people is estimated to grow by 32.2% between 1990 and 2020 (driven by immigration). Australia is the fourteenth largest world economy, with a Gross Domestic Product (GDP) in 2000/2001 of $670[1] billion (around US$361 billion).

Australia is in many respects unique among Annex I countries. It has a wide range of climatic zones, rapid population growth, long distances separating urban centres, and land use patterns that are still undergoing significant change. Energy generation in Australia is dominated by low-cost fossil fuels, and exports (particularly primary products and energy and energy-intensive products) play a major role in the economy.

Along with a central Commonwealth government, Australia has eight self-governing States and Territories (New South Wales, Victoria, Queensland, South Australia, Western Australia, Tasmania, the Australian Capital Territory and the Northern Territory) and more than 700 local governments. As the Commonwealth, State and local governments share responsibility for reducing greenhouse gas emissions and protecting and enhancing greenhouse sinks, coordinated action through the National Greenhouse Strategy is required to effectively implement climate change policy.

The structure of Australia's economy has a major impact on its greenhouse gas emissions profile and its consequent approach to addressing climate change. Energy and greenhouse gas intensive industries are significant contributors to Australia's economy. Coal, oil and gas production and heavy engineering and aluminium industries are significant sources of income.

Fossil fuels are the dominant energy source, primarily because low cost fossil fuels are abundant, hydro-electric resources are limited by available water and nuclear power is not utilised. Australia also has a number of energy intensive and export-oriented industries, such as aluminium smelting and steel production, built around these natural resources. In contrast to most other OECD countries Australia is also a significant energy exporter – over 70% of its total energy production was exported in 2000/2001. By providing the world market with energy-intensive products and less greenhouse-intensive energy sources such as liquefied natural gas (LNG), Australia displaces emissions that would otherwise occur in these markets.

Agriculture accounts for around 26% of total Australian merchandise exports, with exports worth just over $30 billion in 2000/2001. Agricultural and pastoral properties in Australia cover more than 450 million hectares, of which nearly 90% is used for grazing livestock – particularly cattle and sheep. Unlike most other industrialised countries, land use patterns in Australia are still changing and the Land Use Change and Forestry sector is a net source of greenhouse gas emissions.

Australian native forests cover about 164 million hectares (or about 21% of the continent). Most of this is woodland and mallee trees. Australia also has more than 1.3 million hectares of forest plantations, of which 71% are introduced pines and 29% are native species, mostly eucalypts. Less than 1% of the plantation estate is harvested each year.

[1] All monetary numbers are in Australian dollars unless otherwise specified.

NATIONAL GREENHOUSE GAS INVENTORY

The National Greenhouse Gas Inventory is an important tool in the development of Australia's climate change policy and is a key means of appraising progress in implementing greenhouse response measures. Australia's Inventory is compiled annually, reflecting international and national commitments. The Inventory results in the *Third National Communication* are taken from the most recent Inventory for the period 1990 to 2000.

Consistent with its unique national circumstances, including the continuing importance of natural resource development to the economy, Australia has a distinctive profile of greenhouse gas emissions:

- energy-intensive primary energy production, minerals processing and transport continue to drive rapid growth in the Energy and Fugitive sector emissions;
- the Land Use Change and Forestry sector, which represents a significant component of the inventory, is a net source of emissions (as land clearing emissions exceed sequestration of carbon by greenhouse sinks); and
- emissions associated with agriculture are a significant component of the Inventory.

Australia's 2000 Inventory provides a comprehensive inventory of human induced greenhouse gas emissions and sinks. There are some different international rules for compiling Inventories under the UNFCCC and for Australia's 108% Kyoto target. The different rules mean that there are different estimates of the level of emissions and trends in emissions reported.

According to the UNFCCC inventory accounting rules, Australia's greenhouse gas emissions amounted to 503.3 Mt CO_2- equivalent (Mt CO_2-e) in 1990 and 535.3 Mt CO_2-e in 2000, an increase of 6.3%. The combined Energy sector (Stationary Energy, Transport and Fugitive Emissions from Fuel) accounts for about 70% of the total emissions. Between 1990 and 2000 all sectors were net emitters. Table 1.1 summarises emissions and changes since 1990. These estimates follow UNFCCC accounting provisions.

According to the Inventory accounting provisions that relate to Australia's 108% Kyoto emissions target, the growth in emissions between 1990 and 2000 is 5%. The main difference in the Inventory accounting rules for the 108% Kyoto target relates to the way forest sinks are treated.

Table 1.1 Net greenhouse gas emissions and removals by sector, 1990-2000 (Mt CO_2-e) (UNFCCC accounting)

Sector	1990 Mt CO_2-e	2000 Mt CO_2-e	Change Mt CO_2-e %	Change
Energy	298.7	371.8	73.1	24.5
Stationary Energy	*208.5*	*264.0*	*55.4*	*26.6*
Transport	*61.5*	*76.3*	*14.9*	*24.2*
Fugitive	*28.8*	*31.5*	*2.8*	*9.6*
Industrial Processes	12.0	10.3	-1.7	-14.3
Agriculture	91.3	98.4	7.1	7.8
Land Use Change & Forestry	85.9	38.0	-47.9	-55.8[a]
Waste	15.3	16.7	1.4	9.2
Total net national emissions	**503.3**	**535.3**	**32.0**	**6.3[a]**

(a) This does not equate to Kyoto target accounting. Using the Kyoto target methods, growth in national emissions between 1990 and 2000 is 5%.

Using the UNFCCC Inventory rules as a basis for analysis, the largest percentage increases in emissions were in the Stationary Energy (26.6%), Transport (24.2%) and Fugitive (9.6%) sectors. Smaller increases occurred in the Waste and Agriculture sectors. Emissions from Industrial Processes decreased by 14.3%. Net Land Use Change and Forestry emissions decreased by 55.8% between 1990 and 2000.

In terms of emissions by gas type (see Table 1.2), CO_2 makes the largest contribution to Australia's total emissions, accounting for 71.9% of all emissions in 2000 compared with 70.7% in 1990. Methane accounted for 22.6% of CO_2-e emissions in 2000, reflecting Australia's substantial agricultural industry, although its share has declined slightly since 1990. Emissions of perfluorocarbons (PFCs) declined between 1990 and 2000 due to improved process control and monitoring in the aluminium production process.

Table 1.2 Net greenhouse gas emissions and changes by gas, 1990-2000 (UNFCCC accounting)

Greenhouse Gases	1990 Mt CO_2-e	2000 Mt CO_2-e	1990 % of Total	2000 % of Total	Changes Mt	Change in emissions %
CO_2	356.0	379.9	70.7	71.0	23.9	6.7
CH_4	118.9	121.1	23.6	22.6	2.2	1.8
N_2O	23.2	31.9	4.6	6.0	8.7	37.6
PFCs and SF_6	4.1	1.0	0.8	0.2	-3.1	-76.2
CO_2-e[(a)]	1.2	1.5	0.2	0.3	0.3	25.2
Total CO_2-e	**503.3**	**535.3**	**100.0%**	**100.0%**	**32.0**	**6.3**[(b)]

(a) Includes confidential CO_2 and N_2O emissions from the Industrial Processes source categories nitric acid and ammonia production.

(b) According to accounting provisions applying to the 108% Kyoto target, the change in emissions between 1990 and 2000 is 5%.

A major effort is being devoted to improving the basis for determining emissions estimates in the Land Use Change and Forestry sector. The National Carbon Accounting System was initiated in 1998 specifically to address the estimates of emissions and sinks in land-based sectors. The first products from the program are now available and have been used to compile the Forest and Grassland Conversion (land use change) estimates in the 2000 Inventory. It is expected that future products will result in revisions to the remaining Land Use Change and Forestry subsectors.

As part of the continuous improvement process for the Inventory, the Australian Greenhouse Office is developing an integrated Australian Greenhouse Gas Emissions Information System that will improve quality and efficiency of compiling and reporting national and State emissions and sinks estimates. The methodologies and data of sectors other than Land Use Change and Forestry are also currently being reviewed in turn. The initial focus of the reviews is on key sources, including electricity generation and livestock.

POLICIES AND MEASURES

Consistent with its unique emissions profile, Australia's greenhouse gas emissions occur across a range of sectors in the economy. In response, Australia has established a whole-of-government Commonwealth agency – the Australian Greenhouse Office – to coordinate climate change policy and deliver greenhouse programs. It has developed a strategic framework of policies and measures for advancing nationwide its domestic greenhouse action across all sectors of the economy – the National Greenhouse Strategy.

The Australian Greenhouse Office was established in 1998 and leads Australia's climate change policy implementation and the delivery of the nearly $1 billion of Commonwealth policies and measures for greenhouse gas abatement, including $180 million Safeguarding the Future package (1997) and programs ($796 million) under Measures for a Better Environment (1999).

The National Greenhouse Strategy was developed by Commonwealth, State and Territory governments and launched in 1998. Under the National Greenhouse Strategy, some 86 individual measures are grouped into eight sectoral 'modules', reflecting the full range of policy approaches, from voluntary action and strategic investment to regulation and market measures.

These policies and measures are directed toward the achievement of three overarching goals:

- fostering knowledge and understanding of greenhouse issues;
- limiting greenhouse gas emissions; and
- laying the foundations for adaptation to climate change.

The National Greenhouse Strategy is scheduled for review in 2002.

The development of **partnerships** between government, industry and the wider community to limit greenhouse gas emissions is a vital component of the National Greenhouse Strategy and is particularly important for the success of policies and measures that cut across a number of greenhouse sectors.

- The $400 million Greenhouse Gas Abatement Program (GGAP) established in 1999 supports large-scale, cost-effective and sustained abatement by industry and the community. To date the Commonwealth has invested approximately $150 million for a range of projects including energy, transport fuels, mining, industrial processes and agriculture. It is expected that these projects will abate over 26 Mt CO_2-e in the first commitment period (2008 – 2012) under the Kyoto Protocol to the UNFCCC.
- Greenhouse Challenge – a joint voluntary initiative between the Commonwealth and industry with over 700 members – has been expanded to allow an even greater uptake by industry. Firms are developing inventories of their greenhouse gas emissions, developing action plans to reduce those emissions and reporting on their progress in achieving emissions reductions.
- The strong commitment of local government councils to the Cities for Climate Protection™ (CCP™) Program has made the Australian CCP™ Program the fastest growing in the world.
- The Greenhouse Friendly Program is a voluntary certification and labelling initiative designed to engage consumers on climate change issues and greenhouse gas abatement and to broaden the basis for investment in greenhouse gas abatement.

In recognition of the contribution of **energy** to Australia's growth in greenhouse gas emissions, Australia's greenhouse response involves significant efforts directed at energy production and supply, and energy use to reduce emissions in this sector.

- A number of key strategies have been put in place to improve the efficiency of energy supply and use. The Commonwealth has introduced Generator Efficiency Standards to move fossil fuel electricity generators toward best practice in generation efficiency. The Energy Efficiency Best Practice Program encourages wise energy use in key sectors. Minimum energy efficiency standards for residential and commercial buildings are being introduced into the Building Code of Australia. A joint Commonwealth, State and Territory government program also requires comparative energy labelling and minimum energy performance standards for domestic appliances, commercial products and industrial equipment.
- States and Territories are also focused on improving energy efficiency in government operations. The Victorian Government, for example, has committed to a 15% target for reduction in energy consumption by government agencies. The Northern Territory has also introduced energy reduction targets for its government agencies.
- Through GGAP, the Commonwealth has provided direct support for an increase in cogeneration and improved efficiency in fossil fuel power generation.
- Significant progress has been made in implementing energy market reform throughout Australia, including the introduction of a wholesale electricity market across southern and eastern Australia (representing the bulk of Australia's population) for the supply and purchase of electricity. Commonwealth, State and Territory governments have recently reaffirmed their commitment to ongoing reform, including attention to addressing the greenhouse implications of the reform process. This is expected over time to bring about emissions reductions through increased efficiency in energy supply.

As a major element of its greenhouse response in the energy sector, the Commonwealth, States and Territories are also providing a major boost to the commercialisation and uptake of renewable energy. To complement innovative renewable energy legislation, up to $378 million has been committed by the Commonwealth Government for ongoing development of the renewable energy industry.

- Under the Mandatory Renewable Energy Target wholesale energy purchasers are required to purchase increasing amounts of electricity generated from renewable sources. Innovative trading rules allow the target to be met cost-effectively. In force since 1 April 2000, the target of an additional 9 500 GWh by 2010 will mean an increase of more than 50% above 1997 levels of renewable energy generation.
- The Renewable Energy Action Agenda was developed in close cooperation between industry and government, and establishes a policy framework to promote growth in a commercially viable and internationally competitive Australian renewable energy industry.
- State and Territory governments in New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and Western Australia have jointly established a National Green Power Accreditation Program, under which electricity customers can elect to pay a premium to their energy retailers for the supply of electricity generated from renewable sources (solar, wind, biomass, hydro and geothermal).
- The Commonwealth's Renewable Energy Showcase Program and the Renewable Energy Commercialisation Program support and promote leading edge and strategically important renewable energy projects with strong commercial potential. These include a range of innovative applications using wind, solar, small hydro, but also leading-edge developments in wave, tidal, geothermal and bioenergy. The Renewable Energy Equity Fund provides equity finance to small innovative renewable energy companies.
- The Commonwealth and States and Territories have also implemented highly successful programs to support the wider diffusion of already available technologies. Under the Commonwealth's Photovoltaic Rebate Program, up to $31 million is available as cash rebates to householders and owners of community use buildings who install grid-connected or stand-alone photovoltaic systems. The Renewable Remote Power Generation Program provides support for the conversion of diesel based electricity supplies to renewable energy technologies in remote areas of Australia. A number of these programs are delivered cooperatively by the Commonwealth, States and Territories.
- Several States and Territories have also implemented rebate programs for solar hot water heaters, as well as other programs to assist the commercialisation of sustainable energy technology. For example, the New South Wales Sustainable Energy Development Authority has promoted the uptake of sustainable energy technologies through its Renewables Investment Program, Cogeneration Program and other rebate programs. In Tasmania, planning is under way for the development of a wind farm in the north-west of the State.

In the **transport** sector, Australia has implemented a number of actions to reduce greenhouse gas emissions from passenger and freight transportation, ranging from measures improving vehicle fuel efficiency to reducing the demand for travel and encouraging greater use of public transport.

- The Commonwealth introduced a Fuel Consumption Labelling Scheme in January 2001, under which, all new cars sold in Australia are required by law to carry a fuel consumption label on the windscreen at the point of sale.
- The Commonwealth has also introduced programs (costing $83 million) aimed at increasing the use of alternative fuels, especially compressed natural gas (CNG) and liquefied petroleum gas (LPG), especially in medium to heavy road vehicles in order to reduce greenhouse gas and other vehicular emissions from the transport sector.

- As part of GGAP, the Commonwealth is supporting the innovative use of biofuels that can reduce greenhouse emissions from vehicle use.
- A number of States and Territories are also encouraging conversion of buses from diesel to cleaner burning gas, as well as other measures to reduce transport-related emissions. In Western Australia, for example, the TravelSmart Program aims to change people's travel habits and motivate them to use greenhouse-friendly alternatives such as public transport, cycling or walking. The South Australian Living Neighbourhoods Program is also aimed at changing travel behaviour of commuters.

In the **agriculture** sector, action has also been taken to reduce greenhouse gas emissions through sustainable farming practices to support productivity and the long-term viability of agricultural enterprises.

- The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is continuing with its development of a vaccine to reduce livestock methane emissions. In trials the vaccine has shown the potential to reduce methane emissions, as well as enhance live weight gain and wool growth.
- Greenhouse Challenge has been expanded to include significant numbers of enterprises in the agriculture sector.
- A strategic framework for greenhouse and agriculture, being prepared under the auspices of the Commonwealth's Greenhouse and Agriculture Taskforce, will identify priority actions, information needs and abatement options for key agricultural industries.

Increasing the area of **forestry** production and increasing vegetation cover, particularly through reforestation and farm forestry, provide important opportunities for carbon sequestration, in addition to other environmental benefits such as controlling land and water salinity and improving biodiversity conservation.

- Several programs under the Commonwealth's Natural Heritage Trust (costing $2.5 billion over 11 years) have beneficial greenhouse outcomes. Bushcare is aimed at protecting, enhancing and increasing native vegetation in the landscape, while the Farm Forestry Program encourages the incorporation of commercial tree growing and management into farming systems on cleared agricultural land.
- The Commonwealth and States and Territories have also implemented plantation strategies. The Plantations for Australia – 2020 Vision aims to remove impediments to Australian plantation establishment – the rate of plantation expansion has more than quadrupled between 1995 and 2000, from 30 300 hectares to 125 000 hectares per year. Up to $3 billion (of mainly private capital) could be invested to establish new plantations by 2020.
- One of the objectives of the $1.4 billion National Action Plan for Salinity and Water Quality – endorsed by the Commonwealth, States and Territories in November 2000 – is to prevent, stabilise and reverse trends in dryland salinity through revegetation and vegetation protection. It is expected the plan will substantially enhance Australia's greenhouse sink capacity.

Significant greenhouse action has also been taken by the Commonwealth and States and Territories to reduce greenhouse gas emissions in relation to the **industrial processes**, **fugitive emissions** and **waste sectors**. For example, under the Australian Capital Territory's No Waste to Landfill by 2010 Strategy electricity is generated from methane extracted from landfill and fed into the electricity grid. The Queensland Government's Cleaner Energy Strategy is assisting the coal industry to capture and use waste gas from coal mines.

PROJECTIONS

Emissions projections across all sectors have undergone a process of continuous improvement since Australia's *Second National Communication* in late 1997. Further work is in train to build on these estimates, particularly in the Land Use Change and Forestry sector (where the current projections are indicative).

The rules and practices for assembling projection of future emissions of greenhouse gases for the purposes of the UNFCCC and for Australia's 108% Kyoto target have some important differences. The two approaches are essentially the same for energy, agriculture, industrial processes and waste sectors, and for the land use change component of the land use change and forestry sector. However, the projections are compiled on a very different basis when estimating the contributions of forestry sinks, under the UNFCCC and under the Kyoto target. As the rules are different, the projections results are different.

According to the UNFCCC accounting practices, emissions across all sectors are estimated to reach 580 Mt CO_2-e in 2010 – a 16% increase over 1990 levels. The projection of emissions includes the performance of greenhouse gas abatement measures which are projected to deliver in aggregate, a reduction of 59 Mt CO_2-e in 2010.

However, assessment of Australia's emissions projections according to Kyoto target rules shows that over the period 2008–2012 emissions would be 111% of 1990 levels on average. The period 2008-2012 is used here because this is the five year interval which is applicable to Kyoto targets.

The international guidelines for preparation of National Communications focus upon emissions projections developed in accordance with the specific rules applying for the UNFCCC. Hence, the following analysis of sectoral trends is described on the basis of these UNFCCC rules.

Sectoral contributions to total emissions under the UNFCCC account are dominated by energy, agriculture and land use change and forestry (Table 1.3).

- The Energy sector (comprising stationary energy, transport and fugitive) continues to be the most significant source of greenhouse gas emissions (approximately 72% of total emissions in 2010).
- Agriculture emissions are not projected to grow significantly and will contribute approximately 16% of emissions in 2010.
- Industrial process emissions are expected to grow rapidly, but from a small base. They contribute approximately 4% of projected emissions in 2010.
- The contribution of the Waste sector shrinks slightly as emissions are maintained at 1990 levels.
- The Forestry and Other sub-sectors (according to indicative projections) are expected to sequester approximately 4% of total emissions in 2010.
- Land Use Change emissions are projected to fall to approximately 10% of total net emissions in 2010 from 21% in 1990.

For information on individual sectoral projections refer to *Chapter 5 – Projections*.

If the sectoral breakdown were presented following the rules for Kyoto targets, the broad picture would be the same, except in the case of forestry where there would be a significantly different contribution in the emissions trends.

Table 1.3 Net greenhouse gas emission projections[1], 1990 and 2010 (UNFCCC accounting)

	1990[1,2]	2010 Business as usual		Measures[3]	2010 'with measures'	
	Mt CO_2-e	Mt CO_2-e	% of 1990	Mt CO_2-e	Mt CO_2-e	% of 1990
Energy	299	453	151	35	418	139
Stationary	*209*	*313*	*150*	*28*	*284*	*136*
Transport	*61*	*95*	*154*	*4*	*91*	*148*
Fugitive	*30*	*45*	*153*	*3*	*43*	*144*
Agriculture	91	96	105	1	95	104
Waste	15	23	152	8	15	100
Industrial Processes	12	29	242	5	24	201
Impact of GGAP[4]				11	-11	
Sub total	418	600	144	59	541	130
Land Use Change[5] and Forestry[6]	80	ne	ne	ne	39	49
Land Use Change[5]	*107*	*ne*	*ne*	*ne*	*61*	*57*
Forestry[6] & Other	*-27*	*ne*	*ne*	*ne*	*-22*	*81*
Total[7]	**498**	**ne**	**ne**	**59**	**580**	**116**

1. Note that the total emissions for 1990 would be different for the Kyoto target baseline, because of the different rules for forestry sinks.
2. With the exception of the Land Use Change and Forestry sector, the 1990 estimates utilised for developing projections were from the 1999 National Greenhouse Gas Inventory. These are slightly different from the 2000 estimates used in *Chapter 3 – National Greenhouse Gas Inventory*.
3. Details of measures are provided in *Chapter 4 – Policies and Measures*.
4. The total estimated abatement from the Greenhouse Gas Abatement Program. Impacts occur in a range of sectors.
5. Land Use Change projections are for CO_2 only.
6. Forestry as defined under the UNFCCC includes all commercial forestry activity and environmental tree planting in Australia. The Kyoto Protocol accounting provisions for new (post-1990) forest plantations are different and are not shown in Table 1.3.
7. Columns may not sum to totals due to rounding.

ne Not estimated.

VULNERABILITY, IMPACTS AND ADAPTATION

The latest climate change projections, released by the Commonwealth Scientific and Industrial Research Organisation in May 2001, are based on the Intergovernmental Panel on Climate Change's Third Assessment Report. These suggest that by 2030 annual average temperatures could be 0.4 to 2.0ºC higher over most of Australia, with slightly less warming in some coastal areas and Tasmania, and slightly more warming in the north-west of Australia.

By 2030, most climate models project an annual average rainfall decrease in south-west Australia and in parts of south-east Australia and Queensland. Annual rainfall averages in the tropical north of Australia are not projected to change from current conditions. There could be an increase in the frequency and intensity of extreme weather events. For example, there could be more frequent heavy rainfall events, even where average rainfall decreases. Generally, warmer conditions would lead to increased evaporation, which when combined with the projected changes in rainfall, would result in a decrease in available moisture and greater moisture stress.

The vulnerability of Australia's natural and human systems to climate change differs to some extent across regions within Australia. Australian ecosystems that are particularly vulnerable to climate change include coral reefs, arid and semi-arid habitats in south-west and inland Australia and Australian alpine systems. Increases in the intensity of heavy rains and tropical cyclones could increase the risks to human life and property and expose natural ecosystems to more flooding, storm surges and wind damage. Australia's water supply and hydrology systems are likely to become increasingly vulnerable to climate change due to projected drying trends over much of Australia. South-west Australia is likely to be most affected by increased temperatures and reduced rainfall.

Impacts of climate change on agriculture are a key concern to Australia because of this sector's importance to the national economy. Predicting the likely impacts of climate change on agriculture is complex because change in different climatic factors can work in different ways. Increased CO_2 boosts plant growth and increases water use efficiency, while projected increases in temperature and extreme events are likely to reduce production. Adaptation through modifying crop varieties and farm management practices can improve yields and crop value.

More than 80% of Australia's population resides within 50 km of the coast. With further growth anticipated, the communitys risk from extreme events – notably tropical cyclones, storm surges and flooding of rivers in deltas and other outflow regions – is increasing.

Adaptation measures are being examined as these represent an important strategy in reducing the adverse impacts of climate change and enhancing beneficial effects. All levels of government are placing greater priority on adaptation through development of a coordinated program of activity.

FINANCIAL RESOURCES AND TECHNOLOGY TRANSFER

In accordance with its commitments under the UNFCCC, Australia has provided significant financial resources to assist developing countries to respond to climate change since the 1996/1997 financial year. These resources have been delivered through bilateral, regional and multilateral channels. Since 1996/1997, Australia has contributed over $160 million to bilateral and regional climate change-related overseas aid activities that help developing countries to reduce net greenhouse gas emissions and adapt to climate change. These resources have been aimed at transferring "soft" technologies through support for capacity building, information networks, training and research, as well as hardware. The primary focus of this bilateral funding is in forestry, land management and renewable energy. In addition, Australia has funded a significant program of assistance to help vulnerable Pacific Small Island Developing States to monitor and adapt to climate change.

Australia has also continued to make financial contributions to multilateral institutions and programs, many of which have significant climate change programs. For example, Australia has contributed approximately $30 million since 1996/1997 to the Global Environment Facility (GEF). It has also given over US$2.8 million to the World Bank's National Strategy Studies program to assist governments in Thailand, Vietnam, Indonesia, Sri Lanka and Papua New Guinea in understanding market-based mechanisms for greenhouse gas emission reductions and building their capacity to benefit from such markets.

To progress Australian interests in international collaborative projects to reduce greenhouse emissions, $6 million was allocated through the International Greenhouse Partnerships Program. A range of international cooperation projects has been established in several countries, via the Activities Implemented Jointly pilot phase, to gain experience. To date, fifteen pilot projects have been established in nine

countries – Chile, Fiji, India, Indonesia, Malaysia, Mauritius, Peru, Solomon Islands and Vietnam – encompassing a range of project types, including solar, micro-hydro, wind, landfill gas recovery, carbon sequestration, energy efficiency, fugitive gas capture, fuel substitution and rural electrification.

RESEARCH AND SYSTEMATIC OBSERVATION

Australian scientists have continued to play an active role in climate, climate change and climate variability research. This commitment to research, combined with Australia's geographic location and size, means that it continues to have the most comprehensive research and monitoring activities related to climate change in the Southern Hemisphere. Australia is regarded as a leading player in international research in this area.

Climate research in Australia is carried out in relation to climate processes, modelling, impacts, mitigation and adaptation, and is conducted at both Commonwealth and State government level and by many organisations and institutions. The Commonwealth Government supports a broad base of greenhouse science research and systematic observation aimed at advancing understanding of global and regional climate change, and its possible effects on Australia's natural and managed systems. For example, the Australian Greenhouse Science Program, managed by the Australian Greenhouse Office, provides strategic research funding to Commonwealth agencies such as the Atmospheric Research and Marine Research divisions of the Commonwealth Scientific and Industrial Research Organisation, the Bureau of Meteorology Research Centre and the National Tidal Facility. Australian researchers also contribute significantly to international climate research through their direct participation in the activities of the World Climate Research Program, the World Climate Impacts and Response Strategies Program, and other climate-related programs, such as the International Geosphere-Biosphere Program and the International Human Dimensions Program.

The Australian Climate Observing System Plan, completed in December 1997, provides the framework for Australia's systematic observation of climate. Australia contributes to the systematic observation of the global climate under the Global Climate Observing System through the provision of meteorological and oceanographic observations and through participation in international terrestrial and space-based observing programs.

Further detailed information on Australia's meteorological, atmospheric, oceanographic and terrestrial climate observing systems can be found in Australia's national communication to the UNFCCC on systematic observation, *Australia's Global Climate Observing Systems – A Detailed National Report on Systematic Observation of Climate*, prepared by the Bureau of Meteorology and available from its website at **http://www.bom.gov.au**.

EDUCATION, TRAINING AND PUBLIC AWARENESS

The level of promotional and educational activity related to climate change has increased significantly during the past five years. Furthering understanding of greenhouse through the formal education sector has been a key feature of Australia's national greenhouse response. The Commonwealth and State and Territory governments have endorsed a national framework for greenhouse education, with a number of governments providing support and materials to promote greenhouse education in schools. For example, the Australian Greenhouse Office has developed a school resource kit that has been distributed nationally through the Australian Science Teachers Association and sponsored the development of curriculum materials by professional teachers' associations.

Progress is also being made in incorporating greenhouse-related elements into relevant areas of tertiary education and vocational training curricula. For example, the Australian Greenhouse Office is funding projects aimed at incorporating sustainable energy principles into national training packages. Universities are also giving increased emphasis to greenhouse-related issues in their courses as well as in their research. A number of universities are offering courses in renewable energy and related areas through the Australian Cooperative Research Centre for Renewable Energy.

Australia has also continued to undertake a broad range of public information and education projects as part of its national greenhouse response. Activities undertaken have included the production of booklets, journals, books, websites, demonstration projects, training programs and media advertising. During February 2001, the Commonwealth Government conducted a nationwide television, newspaper and magazine public information campaign to raise awareness of the greenhouse issue, as well as actions that individuals can take to reduce greenhouse emissions. Commonwealth, State and Territory government departments and agencies also produce a range of publications aimed at keeping industry and the general community informed of greenhouse-related initiatives, success stories and developments in national and international policy.

The Australian Greenhouse Office also operates a telephone information service that provides the general community with access to publications, Australian Government climate change program information and advice on actions to reduce greenhouse emissions. It is supported by a comprehensive website that provides detailed information on Commonwealth climate change programs. A number of States and Territories have also created energy information centres that provide information on government energy policies and programs, energy safety and publications, as well as advice on a wide range of energy saving ideas for consumers and businesses.

CHAPTER TWO

NATIONAL CIRCUMSTANCES – AUSTRALIA IN CONTEXT

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.

A range of individual factors are important in understanding the opportunities and constraints that Australia faces in engaging in emission mitigation and sink augmentation activities, such as Australia's climate, geography, demographic trends, natural resource base, political and institutional structure, economic composition, trading relationships, energy production and consumption profile. Identifying Australia's environmental and economic vulnerability to the effects of climate change requires a thorough examination of all these factors.

Australia's size, diverse environments and above OECD-average population growth, concentrated along an extensive coastline, exposes Australia to a wide range of potential impacts and costs arising from climate change, including disruption of the environment and human activities. These effects could include an increase in severe storms, floods and droughts, erosion of coasts due to sea level rise, risks for human health, an increase in the range and spread of tropical diseases and pests, and adverse impacts on biodiversity, agricultural industries, manufacturing industry and social infrastructure. Further information on these impacts is contained in *Chapter 6 – Vulnerability Assessment, Climate Change Impacts and Adaptation*.

Australia is vulnerable to the potential economic impacts of international and domestic actions to reduce greenhouse gas emissions. Such vulnerability is due to factors such as Australia's reliance on long haul transport over a large land areas and its widely dispersed natural resources and remoteness from overseas markets.

Australia has few economically viable alternatives to sourcing most of its energy from fossil fuels, with no nuclear energy and limited hydro-electricity capacity. Ongoing market reform, improved business energy efficiency and increasing capacity from cogeneration, gas and renewables will all provide future sources of energy.

Australia is the world's leading exporter of coal and has a large and relatively inexpensive supply of fossil fuels upon which energy intensive industries such as aluminium smelting and steel production have been built. These industries make a significant positive contribution to economic growth, employment and regional development in Australia.

These national circumstances as outlined above have been considered in formulating Australia's response to climate change, recognising that effective climate change policies must accommodate environmental protection, conservation, economic growth and social justice.

This chapter provides the framework within which Australia's response to climate change can be better understood. It outlines Australia's particular national circumstances and their implications for climate change issues and policy making.

GOVERNMENT STRUCTURE

Australia consists of a federation of a central government (the Commonwealth) and eight self-governing States and Territories (Victoria, New South Wales, Queensland, Western Australia, South Australia, Tasmania, the Australian Capital Territory and the Northern Territory). In addition, there are around 730 local governments in Australia.

The complexity of Australia's constitutional arrangements has implications for greenhouse response action. As the Commonwealth, State and local governments share responsibility for reducing greenhouse gas emissions and protecting and enhancing greenhouse sinks, coordinated action is required to effectively implement climate change policy. All three levels of government have endorsed the National Greenhouse Strategy, in order to provide a coordinated, strategic, national approach to the challenge of climate change.

With the establishment of the Australian Greenhouse Office (AGO), the Commonwealth Government is able to provide a whole-of-government approach to greenhouse matters. The AGO is responsible for the coordination of domestic climate change policy and provides a central point of contact for stakeholder groups. It also seeks to influence the international agenda by engaging in international developments and coordinating Australia's domestic policy basis for international negotiations.

POPULATION

Although Australia's population is relatively small – 19.44 million in 2001 – it has been increasing rapidly, especially when compared with the growth rates of other OECD countries. From 1960 to 1990 Australia's population increased by 64.3%. By contrast, the population of the European Union member states increased by only 15.8%. Over the last decade, Australia's population has grown by approximately 12.8%, while the population of the EU has only increased by around 3.4% during the same period of time. The differences in population growth rate are related mainly to features of immigration intake and age structures. Projections for 1990 to 2020 show a similar trend, with Australia's population projected to grow by 32.2%. This will exert increasing pressure on resources and energy use well into the 21st century.

Most of Australia's population is concentrated in two widely separated coastal regions. By far the largest of these, in terms of area and population, lies in the south-east and east. The smaller of the two regions is in the south-west of the continent. In both coastal regions the population is concentrated in urban centres, particularly the State and Territory capital cities. Half the area of the continent contains only 0.3% of the population, and the most densely populated 1% of the continent contains 84% of the population.

While New South Wales remains the most populous State, the fastest growth has occurred in the Northern Territory and Queensland, with increases of 11.3% and 10.2% respectively in the five years to 1999. In contrast, over the same period, the population of South Australia grew by just 1.8% and that of Tasmania declined by 0.6%.

GEOGRAPHY

Australia has a land area of 7 682 300 km^2, excluding external Territories, making it the sixth largest country in the world. The Australian continent extends from approximately 5° south to 40° south of the equator. Australia is also the only country that has sole occupancy of a continent, providing Australians with unique circumstances relative to other developed countries.

Australia is one of the oldest, lowest and flattest continents, and is, apart from Antarctica, the driest of the continents. The coastline extends for 36 700 km, providing a diverse marine environment including tropical mangrove and coral reef habitats. Oceans also have a major influence on the continental climate.

Australia has been geographically isolated from other continents for 35 million years. As a result, a unique biota has evolved. Australia is recognised as one of 17 countries that are megadiverse. It has the planet's second highest number of reptile species (686), and is fifth in flowering species (23 000) and tenth in amphibian species (more than 180). Many Australian soils are derived from ancient material and tend to be shallow and infertile.

Australia's diverse climate and landscapes, ranging from tropical rainforest to sandy desert, supports a wide variety of land uses which contribute to its unique greenhouse profile. Unlike most other industrialised countries, land use patterns in Australia are still changing. The Land Use Change and Forestry sector is a net source of greenhouse gas emissions. Land clearing, in particular, results in the emissions of greenhouse gases through the burning of cleared vegetation, decay of unburnt vegetation and disturbance of soil as part of the clearing process. This is offset to some extent through carbon sequestration due to regrowth of cleared vegetation. These features of Australia's land management practices are further discussed in *Chapter 3 – National Greenhouse Gas Inventory.*

Conservation of the natural environment is a vital issue for Australia's well being. Considerable importance is placed on identification and conservation of Australia's biodiversity through a scientifically based system of nature conservation areas. The Government is acutely aware of the potential threat of climate change to these natural ecosystems. At June 2000, Australia had 5 128 terrestrial parks and reserves (totalling 60 273 030 hectares) making up 7.84% of the continental landmass, and 148 marine protected areas (totalling 60 308 172 hectares). The vulnerability of these areas to potential climate change impacts is described in *Chapter 6*.

CLIMATE

Australia has a wide range of climate zones – from the tropical regions in the north through the arid expanses of the interior, to the temperate regions in the south. Droughts and floods are common occurrences. Few other Annex I countries are subject to such great year-to-year rainfall variability. This means that the threat of potential climate change impacts takes on a special dimension for Australia.

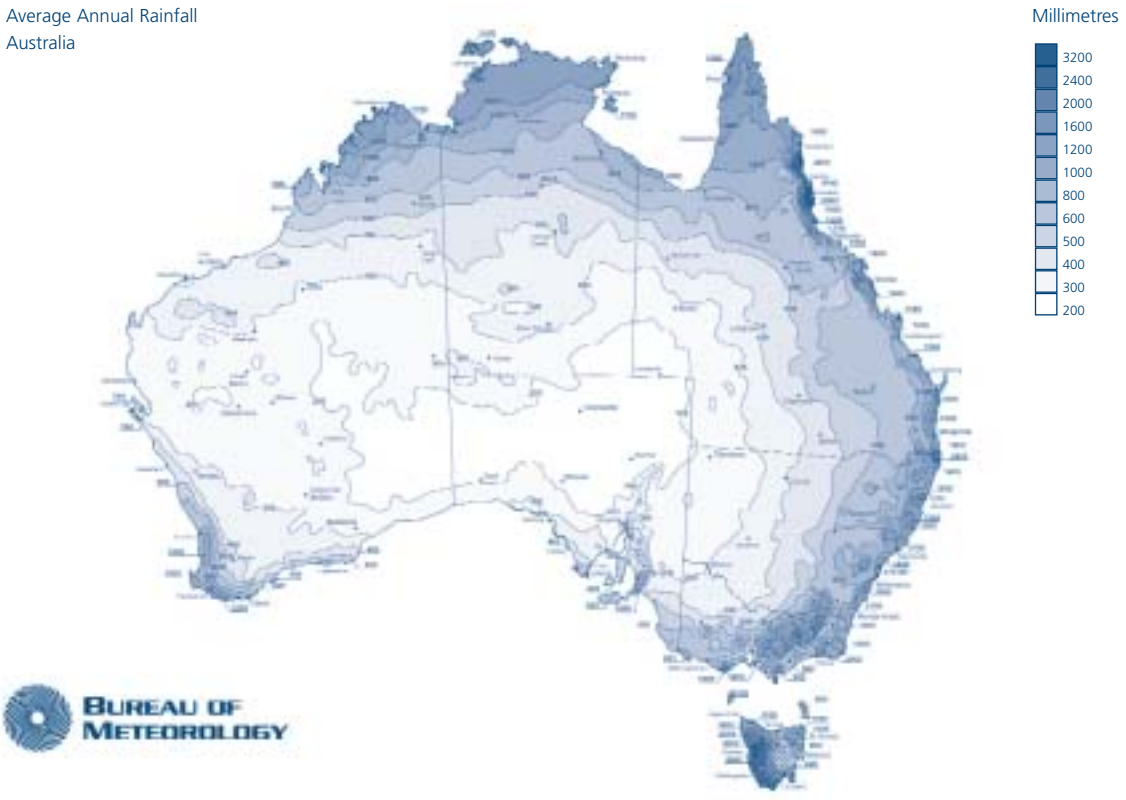
As the driest of all inhabited continents, more than three-quarters of Australia has an average rainfall of less than 600 mm annually and about half the country receives less than 300 mm. Figure 2.1 shows the average annual rainfall distribution.

The most notable feature of the climate is the extreme rainfall variability, which affects much of the continent and is illustrated in Figure 2.2. Australia's geographical location in the southern hemisphere on the western rim of the Pacific Ocean places it at one of the main centres of action of the El Niño – Southern Oscillation (ENSO) phenomenon. ENSO has a significant impact on the climate and is a major contributor to the annual rainfall variability. It has a cycle that varies between two and eight years, which exposes Australia to relatively frequent floods and droughts and high variability in frequency of extreme events such as tropical cyclones, severe storms and bushfires.

High temperatures over large areas of the continent, particularly in summer, can exacerbate the impact of the relatively frequent droughts. The distribution of average daily maximum temperatures across Australia for January is shown in Figure 2.3.

Along the narrow coastal strip, where the majority of the population centres are located, sea breezes moderate maximum temperatures during warmer months. The coastal regions also experience smaller daily temperature ranges than inland areas because of the influence of the sea. Frosts are a regular occurrence during winter in inland areas in the southern half of the continent and can cause serious losses to some agricultural crops. Snowfall in Australia is highly variable in area, depth and duration from year to year, and is usually restricted to south-eastern Australia in areas above about 1 500 metres. High levels of solar radiation are a feature of most of the continent and there are also high winds in some areas. These characteristics of Australia's climate are examined in further detail in *Chapter 6*.

Figure 2.1 Average annual rainfall distribution



Projection: Lambert conformal with standard parrallels 10°S, 44°S. Based on a 30-year climatology (1961-1990)

Figure 2.2 Annual rainfall variability

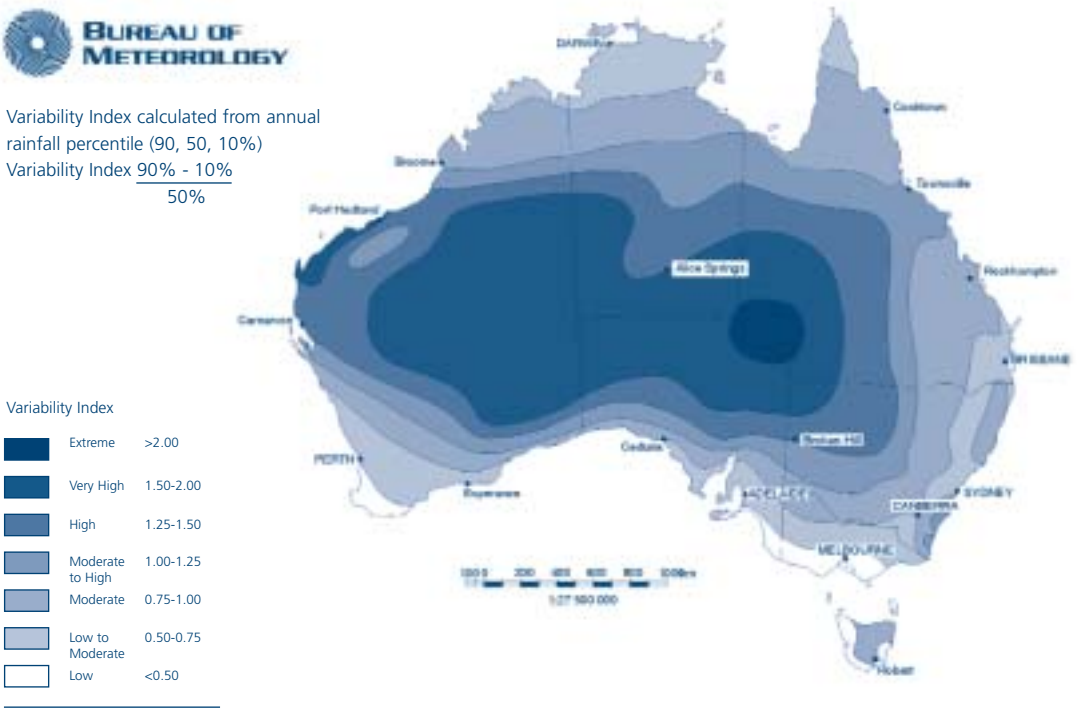
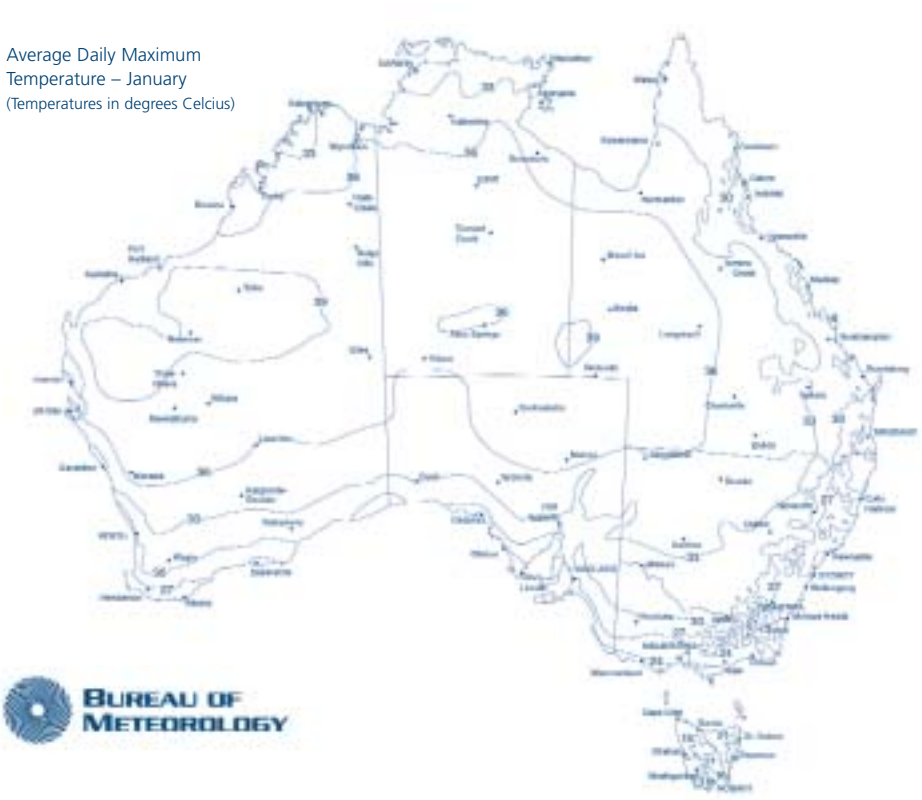


Figure 2.3 Average daily maximum temperatures across Australia for January



Projection: Lambert conformal with standard parrallels 10°S, 44°S. Based on a 30-year climatology (1961-1990)

ECONOMY

The structure of Australia's economy has a major impact on its greenhouse gas emissions profile and its consequent approach to addressing climate change. Australia has the fourteenth largest economy in the world, with a Gross Domestic Product (GDP) in 2000/2001 of $670 billion (or around US$361 billion). The GDP per capita for 2000/2001 was $34 655.

With substantial mineral and resource wealth and abundant low-cost coal reserves, Australia is also a major producer of a range of processed and semi-processed metals. Australia is the world's largest exporter of coal, bauxite, alumina, lead, titanium and zircon, and one of the world's leading exporters of gold, iron ore, aluminium, nickel, zinc and uranium. Mineral resources and resource processing industries generate more than 8.5% of Australia's GDP and more than 400 000 jobs, approximately 5% of all employment in Australia. Mineral resource commodities, worth about $56 billion in 2000/2001, account for 47% of Australia's merchandise exports.

Australia's emissions profile is atypical among OECD countries, and Annex I Parties. Australia is one of only two Annex I countries whose Land Use Change and Forestry sector is a net source of emissions. While the energy sector was the largest source of emissions it accounted for only around 70% of Australia's emissions in 2000 compared with an average of 82% for other Annex I countries. Agriculture was a significantly more important emission source for Australia than for other countries, with much of agricultural produce being exported.

An important feature of Australia's trade profile is the strong trading links with developing countries – particularly in the Asia-Pacific region. Australia has one of the fastest growing export sectors of OECD economies, partly reflecting its proximity to the economies of the Asia-Pacific region and the region's energy-intensive imports. Merchandise exports grew by 8.6% per annum between 1995/1996 and 2000/2001, and those to East Asia at 6.5% over the same period.

No other OECD country shares Australia's position as the dominant exporter of emission-intensive goods to the fast-growing Asia region. Further trade liberalisation and economic integration in the region is likely to further increase Australia's production of energy and greenhouse gas-intensive activities to service growing Asia-Pacific markets.

ENERGY

Australia has vast reserves of low-cost energy. The reserves that can currently be recovered at least cost include brown and black coal, uranium, natural gas, crude oil and condensate, and naturally occurring liquefied petroleum gas (LPG). Total energy production in 1998/1999 was over 12 400 PJ and the Australian Bureau of Agricultural and Resource Economics (ABARE) project production to be about 18 950 PJ in 2014/2015 (refer Table 2.1).

The Energy sector includes the exploration for, and development and recovery of, petroleum (mostly crude oil, natural gas and LPG), coal and uranium mining, the production and distribution of petroleum and coal products, the transformation and distribution of electric power from all primary energy sources (fossil fuels and renewables), and the end-use of energy.

In contrast to most other OECD countries, Australia is a significant energy exporter. In the 2000/2001 period, over 70% of total energy production was exported (valued at $26 billion or 21% of Australia's total export earning).

Energy consumption in Australia is dominated by fossil fuels with major consumers being the electricity generation sector (29%), the transport sector (25%) and the manufacturing sector (24%). Combined, these sectors account for almost 80% of Australia's total energy consumption.

The Transport sector is the second largest sector in terms of energy use – a share that has remained static over the last 30 years. The sector is dominated by road transport, with petroleum products accounting for around 99% of the sector's energy needs.

Table 2.1 Australian energy supply, trade and consumption, by fuel in energy units actual 1998/1999, projected 2014/2015

Energy Product	Production (Petajoules)		Consumption (Petajoules)		Exports (Petajoules)
	1998/1999	2014/2015	1998/1999	2014/2015	1998/1999
Black coal	6051.1	8066.1	1367.0	1374.1	4824.4[3]
Brown coal	647.3	594.4	647.3	594.4	0.0
Renewable[1]	282.2	319.3	282.2	319.3	0.0
Petroleum[2]	1135.7	1180.3	1675.8	2039.3	749.9
Natural gas	1306.1	3038.2	880.7	1759.8	425.4
Uranium	3001.4	5640.0	0.0	0.0	2814.8
Total	**12423.8**	**18950.5**	**4629.7**	**6086.9**	**8814.5**

1. Includes wood, wood waste, bagasse, hydro-electricity and solar.
2. Includes crude oil, condensate and LPG. Exports include refined petroleum products.
3. Exports include black coal (4821.8 PJ), coke (1.9 PJ) and briquettes (0.7 PJ).

Note: Consumption amount may vary from Production – Exports + Imports because of stock change and statistical discrepancies.

Source: ABARE Energy History, Table N (Supply and Trade), 1998-99 and ABARE Energy History, Table D (Consumption), 1998-99.

Fuel types

Coal

Australia has a very substantial coal resource, with significant reserves of both black and brown coal. Economically recoverable reserves of black and other hard coals are more than 50 billion tonnes – enough to sustain current production levels for some 290 years. Brown coal, used as feedstock for domestic electricity generation, if produced at current levels, would last for a further 800 years.

Oil Australia has significant petroleum reserves. Proven reserves (ie both economic and uneconomic fields at current prices) at the end of 1997 were 1.7 billion barrels of crude oil, 1.7 billion barrels of condensate and 1.9 billion barrels of LPG.

Natural gas

Australia had proven reserves of 2.7 trillion cubic metres (94.5 trillion cubic feet) of natural gas at the end of 1997. Exploration for gas is normally undertaken in conjunction with exploration for other petroleum products, with crude oil the primary target.

Electricity

The electricity generation sector was the largest consumer of energy in 1998/1999 and historically has been one of the fastest growing sectors. This trend reflects increased electrification in all end-use sectors, in addition to the continued strong growth in a number of industries in which electricity is the primary fuel source, such as the commercial services and nonferrous metals sectors. Electricity generation in Australia is dominated by coal fired generation. In 1998/1999, 84% of electricity was sourced from black and brown coal, while hydro accounted for 9% and natural gas 7%. Ongoing energy market reform and a reduction in surplus coal fired capacity will see, in the medium to long term, future additions to capacity coming from cogeneration, gas and renewables.

Renewable energy

Renewable energy currently contributes 5% of Australia's total energy supply and represents 10% of Australia's electricity generation. Combustible renewables, which contribute 5.3%, are made up of bagasse used to generate electricity and steam, and wood for home heating. Australia has little further large-scale hydroelectric generation potential and most of the commercially favourable sites have already been exploited. There is some potential for the development of small-scale hydro. Australia has good access to solar and wind energy resources. There may also be some potential for the development of wave power generation in remote areas that have a low demand for energy.

MARKET STRUCTURE

State and territory governments are responsible for the management of coal reserves in their jurisdictions and legislate the procedures for coal exploration and development. They make the reserves available for companies to develop, and the companies pay royalties for access to the resource. Most mines are privately owned. The few that remain state owned have been corporatised and must compete in the domestic and export markets on the same basis as private mines. With over 80% of black coal exported, the industry is export oriented and subject to international competition.

Commercial exploration and development of oil and gas is undertaken entirely by the private sector. The Commonwealth, States and Territories are responsible for regulating exploration, development, safety, environmental assessment and royalties in their respective jurisdictions. Furthermore, exploration is actively promoted through government sponsored production and dissemination of basic geo-scientific information.

The same government regulations apply to the extraction of natural gas, as to other petroleum product producers. There are 10 major producers of natural gas in Australia, including foreign companies. Producers either sell their gas into the domestic market, or produce for export in the form of liquefied natural gas (LNG).

The competitive National Electricity Market (NEM) was set up in 1998 and supplies electricity to 7.7 million Australian customers on an interconnected national grid that links Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. The NEM is structured around a common pool, or spot market, for trading wholesale electricity. All electricity produced by market generators must be traded through the pool. Approximately, $8 billion of energy is traded through the NEM per year. As well as the NEM, there are three independent systems, which are owned by the different State governments.

Electricity generated by renewable sources either feeds into the NEM, smaller remote area grids or is used on site. A voluntary, industry owned Green Electricity Market is being developed to trade in 'green electricity rights'.

PRODUCTION

Table 2.1 contains the production volumes of coal, oil (petroleum), natural gas and renewable energy. Production of electricity in Australia in 1998/1999 was 202 000 GWh or about 730 PJ.

CONSUMPTION

Table 2.1 presents the consumption volumes of coal, oil (petroleum), natural gas and renewable energy. As Australia does not export electricity, total consumption equals total production. Industrial use consumed the most electricity in 1998/1999 (about 66 000 GWh or 240 PJ), followed by residential use (over 47 000 GWh, or over 170 PJ).

TRADE

Australia is the world's largest exporter of black coal, with over 194 million tonnes exported in 2000/2001. Japan is the leading destination for Australian coal, taking 46% of total exports.

In 1998/1999, Australia exported almost 90 million barrels of crude oil and other refinery feedstock (condensate) and over 15 million barrels of LPG. However, crude oil and refinery feedstock imports of over 187 million barrels, mean that Australia is a net importer of crude oil and refinery feedstocks. LPG imports were about 3 million barrels.

Australia exports about 35% of its natural gas, in the form of LNG. All exports are from the North West Shelf production facility off the coast of Western Australia, which exports about 7.5 million tonnes of LNG annually. Australia has the potential to produce more LNG for export. Australia does not import natural gas.

No electricity is either imported or exported. Australia does not trade in renewable energy. However, Australian companies actively market renewable energy generating products in overseas markets.

ROYALTIES AND TAXES

Companies pay royalties to State & Territory governments for coal extraction, which varies from a fixed amount per tonne, a percentage of sales value, to a fixed amount per gigajoule of energy produced.

A number of different royalties and taxes apply exclusively to the production of petroleum products, depending on where the deposit is located. Natural gas producers face the same royalty and taxes as other petroleum producers.

Australian energy producers are also subject to Australian taxes, such as company tax and goods and services tax (GST), as well as a range of state taxes, such as payroll tax. Companies receive tax credits on GST paid on all business inputs, including fuel and energy.

SUBSIDIES

No direct subsidies apply to energy production from coal, oil, natural gas or electricity, although some industries receive benefits through indirect subsidies. The Commonwealth Government has introduced a number of programs to promote renewable energy, which are discussed in detail in *Chapter 4 – Policies and Measures*.

Intensity of energy use

Like most other OECD countries, Australia has experienced a shift within the economy toward less energy intensive industries. Energy intensity has also changed as a result of changes in real energy intensity, comprising technical effects and changes in the fuel mix. The most notable fuel mix shift over the last

30 years has been towards gas and away from liquid fuels, while growth in coal consumption paralleled growth in total energy consumption.

Aggregate energy intensity (energy consumed per unit of output) of the economy has declined by around 12.3% over the last 25 years. Real energy intensity has decreased by 5.1% over the same period. Real energy intensity excludes the effect of changes in the structure of the economy from energy intensity calculations.

Future capacity additions are expected to come mainly from natural gas plants with higher thermal efficiency as a long-run cost-effective response to demand growth, potentially ameliorating the recent increase in real energy and greenhouse intensity in the energy conversion sector.

TRANSPORT

Travel plays a large part in the national economy and in the everyday lives of most Australians. This is a consequence both of the increasing affordability of travel and the demand for travel due to Australia's geographic size, population dispersal, distances between natural resources and manufacturing and market centres, and distances between Australia and its trading partners. Transport accounted for 14.3% of Australia's total carbon dioxide equivalent (CO2-e) emissions in 2000.

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 locations. As a consequence, the decentralised land use patterns of Australian cities require greater intra-city travel and reliance on private vehicle use.

The average gross vehicle mass of new passenger cars has increased by around 8% over the last 20 years (currently about 2 150 kg). Significant advances in technical fuel efficiency have enabled consumers to access vehicles with improved performance, size and comfort while still achieving small overall gains in fuel efficiency.

Table 2.2 provides summary statistics on the growth, for 1990 and 2000, in the Australian passenger vehicle fleet, the total fuel consumed by these vehicles and the total vehicle kilometres and passenger kilometres travelled.

Table 2.2 Aggregate passenger vehicles, fuel consumption and distance travelled

Year	Passenger vehicles	Fuel consumed (million litres – petrol equivalent)	Total vehicle kilometres travelled (billion km)	Total passenger kilometres travelled (billion km)
1990	7 797 300	14 951	124.4	198.5
2000	9 840 000	17 531	152.8	236.9

Over the decade to 2000, vehicle numbers increased 26.2%, vehicle kilometres travelled by 22.8% and fuel consumption (measured in terms of petrol equivalent) increased by 17.3%. This represented an improvement in average fuel efficiency from 12.01 to 11.47 l/100 km.

Although the overall rail task has grown, rail has lost market share, having accounted for approximately half of the total passenger transport task in the mid-twentieth century to less than 5% in 2000. Over the last 10 years, urban train and tram passenger numbers have increased by 21% and 19%, respectively, whilst non-urban rail passenger numbers declined by 9.5%.

Domestic aviation passengers increased by 50% from 19.2 million in 1991 to 28.8 million in 1999. Total passenger kilometres increased from 18.4 million to 29.8 million over the same period.

The number of passengers on coastal shipping vessels, mainly ferries, increased by 24% from 14.9 million in 1991, to 18.6 million in 1999. However, the total passenger kilometres declined from 501.8 million km in 1991 to 257.2 million passenger km in 1998. The average passenger journey declined from 34 km in 1991 to 15 km in 1998.

Domestic freight transport

Freight transport – both domestic and international – is an important component in the cost structure of Australian industry and the Australian economy. About two-thirds of the total domestic freight task by weight (excluding pipelines) is in bulk commodities. 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.

Preliminary standardised road freight estimates, derived from a model-based forecasting method, indicate that the road freight task grew over 50% from 1990/1991 to 1998/1999 reaching an estimated 136 736 Mt-km.

Emissions from domestic shipping declined from 1990 to 2000 by 32.5%, to an estimated 1.4 Mt in 2000. This was a consequence of the significant decrease in the greenhouse gas intensity of freight carried due to growth in tonne-kilometres, from 93 700 million in 1991 to 120 910 million in 1998, and the more efficient utilisation of the fleet. The total volume of freight carried on domestic shipping increased from 44.1 million tonnes in 1991, to 48.4 million tonnes in 1999. Tonne-kilometres increased from 96 482 million in 1991 to 117 800 million in 1999.

INDUSTRY

Australia's industry output is increasingly made up of services which account for approximately 64% (over $400 billion in 2000/2001 prices) of GDP in 2000/2001. Of the other sectors, manufacturing produced 14.5% of Gross Value Added (around $74 billion), mining produced 5% (over $30 billion) and agriculture, forestry and fishing produced 3.6% (or nearly $18 billion).

Services sector value added has grown by 4.7% per annum since 1995/1996. Over the same period, manufacturing value added grew at a much lower rate (2.8% per annum). The increasing importance of the services sector to the economy is not unique to Australia, as this sector has increasingly dominated the industrial profile of most developed economies over recent decades.

However, Australia's trade patterns do not reflect the structure of its economic output. The manufacturing sector provided the greatest amount of exports by value (29%), followed by the mining sector with 25.8%. The services sector was also a significant exporter, at 18% of Australian exports.

A short profile on key Australian industries is provided below. It is important to note that these industries are, for the most part, both energy and greenhouse gas intensive.

Mineral resources

Coal, oil and gas extraction and production industries are significant sources of income for Australia, and are discussed in the section on Energy within this chapter. Metal ore mining is also an important industry for Australia creating an Industry Value Added earnings of over $7.6 billion. In 2000/2001, the industry produced $18.4 billion worth of exports and directly employed around 23 500 people. Ores produced by the sector include iron ore, bauxite, gold, silver, lead, zinc and copper. The industry accounts for 39% of mining turnover and 29% of sector operating profit. It has a strong export focus with roughly half of its turnover derived from exported product.

Aluminium industry

Australia is the world's largest producer of bauxite and alumina, and the fifth largest producer of aluminium. In 2000/2001, bauxite, alumina and aluminium production generated export earnings of $9.1 billion. 90% of Australia's bauxite is processed into alumina domestically, and a further 23% of this alumina is made into aluminium. The aluminium industry currently employs over 16 000 people and uses about 16% of all electricity and 12% of all natural gas in Australia. Australia is the only Annex I exporter of bauxite and alumna and the only Annex I country where significant growth in these sectors is expected.

Automotive industry

Production of vehicles in Australia is concentrated in the large car segment (non-luxury passenger vehicles of 6 and 8 cylinders). Australian made vehicles dominate this segment, while imports prevail in the others. Industry Gross Product (IGP) in 1998/1999 was about $6 billion. Exports of vehicles and parts totalled $4.1 billion in the year 2000/2001. In 1999/2000, the industry employed over 51 000 people.

Chemicals and plastics industry

IGP from the Australian plastics and chemicals industry was $7.5 billion in 1998/1999, and export earnings were over $2.6 billion. The industry comprises 3 000 firms and is a significant part of the manufacturing sector, employing around 82 000 people. It is a key supplier to industries such as agriculture, automotive, food processing, packaging and telecommunications.

Wood, pulp and paper industry

The wood, pulp and paper industry is one of the largest segments of Australian manufacturing and is particularly important to many rural areas and regional centres. The industry incorporates sawmilling and timber dressing, manufactured wood products, pulp, paper and paper products. The industry contributed around 1% to GDP in 1998/1999 and produced about $4 billion in IGP, including exports of $1.5 billion in 2000/2001, and directly employed some 61 000 people.

Heavy engineering industry

The heavy engineering sector accounts for around 0.6% of GDP and had an IGP of $2.8 billion in 1998/1999. This sector generated over $2 billion of exports and directly employed almost 50 000 people. Structurally, the 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. Despite the

traditional domestic focus of the industry in Australia, there are a number of well established firms responding to new export opportunities through joint ventures and innovation, especially among the mining and construction machinery companies.

WASTE

Currently around 20 million tonnes of waste is disposed of to landfill in Australia annually. This generally comprises 40% organic material, 40% building and construction waste, 18% commercial and industrial waste and 2% household waste.

Industry estimates indicate Australia is recycling 92% of paper packaging, 64% of aluminium cans and 60% of liquid paperboard with about 800 000 tonnes of materials are recycled annually. Greenhouse gas emissions arising from landfill, attributable to anaerobic decomposition of organic waste, accounts for 2.8% of Australia's net greenhouse gas emissions. 12.3% of methane generated in landfills is recovered, mainly for energy generation.

Wastewater currently contributes around 0.3% of net greenhouse gas emissions with the main sources being domestic sewerage and industrial processes (such as food processing, pulp and paper manufacturing and recycling, and textile manufacturing).

BUILDING STOCK AND URBAN STRUCTURE

Since 1911, there has been a slow but steady increase in the size of Australian dwellings, accompanied by a steady decline in the average number of persons per dwelling, from 0.9 to 0.5 persons between 1911 and 1981. The average size of new homes has continued to increase. From 1986 to 1999, the average size increased almost 30% to 185.5 square metres.

The trend away from separate houses towards medium and higher density housing, is related to a number of factors, including the desire of government planners and private developers to meet the demand for lower priced accommodation and housing closer to employment centres. Higher density housing may lead to greater cost effectiveness in the establishment of urban infrastructure and services, such as roads, lighting and waste removal. This in turn could lead to reduced emission of greenhouse gasses through such measures as reduced demand for street lighting and greater reliance on public transport.

AGRICULTURE

Agriculture has traditionally been a significant component of the Australian economy. It currently accounts for just under 3% of GDP, but is more important in trade terms, accounting for around 26% of total Australian merchandise exports. Agricultural exports were worth just over $30 billion in 2000/2001. Australia is the world's largest exporter of barley and wool, the second largest exporter of cotton, canola, beef and sheep meats, the fourth largest exporter of wheat, and a significant exporter of wine and rice.

Agricultural and pastoral properties cover more than 450 million hectares, or about two-thirds of Australia's land surface. Nearly 90% of this area is used for grazing livestock – particularly cattle and sheep. In 1999/2000, around 20 million hectares were sown to grain crops while the national sheep flock was estimated to be 114.5 million and the cattle herd 25.3 million. During the 1990s there was a sharp decline in sheep numbers and a corresponding large increase in the area sown to grain.

Degradation problems persist in large areas of rural and regional Australia. Degradation is limiting agricultural productivity in some regions, requiring costly management responses. Scientific evidence suggests that a number of degradation problems will probably become worse. A high proportion of Australian agricultural land is or will be in the relatively short term (the next 50 years) affected by at least one form of land degradation. Many of these forms of degradation – among them salinity and soil acidity – are insidious, having thresholds beyond which there is ecosystem collapse. A National Action Plan on Salinity and Water Quality in Australia has been established to address these issues. Considerable work is also being undertaken on Environmental Management Systems as a tool for reducing the environmental impacts of agriculture by improving farm management practices.

FORESTRY

Australia's forests are strikingly different from those of the rest of the world, ranging from tropical rainforests to mulga scrub. They are very diverse in their species composition, structure and the fauna they support. Many forest species are unique to Australia with more than 2 800 of the 3 000 tree species being endemic. Eucalypts dominate most forests with more than 700 species found principally in Australia.

The total area of Australian native forest is about 164 million hectares (or about 21% of the continent). Most of this (122 million hectares) is woodland and mallee. Australia also has more than 1.3 million hectares of plantations of which about 71% are introduced pines and 29% are native species, mostly eucalypts. Less than 1% of available area is harvested each year.

Australia's forest industries have an annual turnover of more than $12.2 billion. Forest industries add more than $6 billion of income a year through production, making them one of the largest manufacturing industries in Australia. Annual production contributes more than 1% to GDP. About 80 000 people are directly employed in the forest industries.

CHAPTER THREE

NATIONAL GREENHOUSE GAS INVENTORY

Development and compilation of the National Greenhouse Gas Inventory is a priority element of the National Greenhouse Strategy. The Inventory is an important tool in the development of climate change policy and is a key means of appraising progress in implementing greenhouse response measures.

Consistent with its unique national circumstances, including the continuing importance of natural resource development to the economy, Australia has a distinctive profile of greenhouse gas emissions:

- energy-intensive primary energy production, minerals processing and transport continue to drive rapid growth in the Energy and Fugitive sector emissions;
- the Land Use Change and Forestry sector, which represents a significant component of the inventory, is a net source of emissions (as land clearing emissions exceed sequestration of carbon by greenhouse sinks); and
- emissions associated with agriculture are a significant component of the Inventory.

Australia's Inventory is compiled annually, reflecting international and national commitments. The most recent Inventory covers the year 2000 and has been lodged with the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. This chapter provides a summary of the Inventory results for the period 1990 to 2000.

DEVELOPMENT OF THE NATIONAL GREENHOUSE GAS INVENTORY

Australia has made, and will continue to make, a significant contribution to the Intergovernmental Panel on Climate Change (IPCC) in developing methodologies and good practice in preparing standardised inventories of greenhouse gas emissions. For example, in February 2000 Australia hosted the final IPCC expert meeting for the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* report.

The *Revised 1996 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines) provide the basis for the preparation of Australia's Inventory. Australia has invested significant resources in developing country-specific inventory methodologies, which build upon and are fully consistent with the IPCC approach and reflect Australia's national circumstances.

National expert working groups developed the Australian sectoral methodologies. The methodologies were carefully reviewed by a wide range of professional experts in research institutions, governments, and industry and by community interests. Development of the methodologies and preparation of the Inventory are overseen by an intergovernmental inventory committee.

The methodologies developed by the expert groups were published in a revised set of workbooks to ensure transparency. Subsequent revisions to the methodologies have been published as methodology supplements in conjunction with the annual inventories. Full bibliographic details of Australia's methodology workbooks and supplements are provided at the end of this chapter.

Australia is well advanced in implementing the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. This Good Practice Guide has been applied in the preparation of the 2000 Inventory.

Australia has made a major advance with development of a National Carbon Accounting System, specifically to address the estimates of emissions and sinks from land use change and forestry and to reduce uncertainty in these estimates. It also addresses transparency of reporting and verification of data. The first major products are now available from the System and they have been used to compile the Forest and Grassland Conversion (land use change) estimates included in the 2000 Inventory. It is expected that the remaining components of the Land Use Change and Forestry sector will be estimated for the 2001 Inventory using the National Carbon Accounting System.

As part of the continuous improvement process for the Inventory, the Australian Greenhouse Office is developing an integrated Australian Greenhouse Gas Emissions Information System that will improve quality and efficiency of compiling and reporting emissions and sinks estimates. The methodologies and data for Inventory sectors are currently being reviewed in turn. The initial focus of the reviews is on key sources, including electricity generation and livestock. In recent years, Australia's Inventory has undergone several revisions through the processes of the UNFCCC.

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 Fuel Combustion, Transport and Fugitive);
- Industrial Processes;
- Agriculture;
- Land Use Change and Forestry; and
- Waste.

Following the international guidelines for preparation of National Communications, this chapter on Australia's National Greenhouse Gas Inventory has been prepared in accordance with the Inventory accounting rules that apply for the UNFCCC. However, there are some key differences applying for the accounting rules used for Kyoto targets, notably for forestry sinks. This means that the emissions trends for the purposes of the UNFCCC and the Kyoto target are different.

The Inventory trends show:

(i) According to the Inventory accounting provisions of the UNFCCC, Australia's greenhouse gas emissions amounted to 503 million tonnes (Mt) carbon dioxide equivalent (CO_2-e) in 1990 and 535 Mt CO_2-e in 2000, an increase of 6.3%.

(ii) According to the accounting rules for 108% Kyoto target provisions, emissions amount to 525 Mt in 1990 and 553 Mt in 2000, an increase of 5%.

Emissions Profile (UNFCCC accounting)

Energy related emissions (Stationary Energy, Transport and Fugitive Emissions from Fuel) dominate Australia's emissions profile, contributing around 70% of total emissions in 2000. The Agriculture and Land Use Change and Forestry sectors also make a significant contribution to net greenhouse gas emissions, totalling about 26% (Figure 3.1).

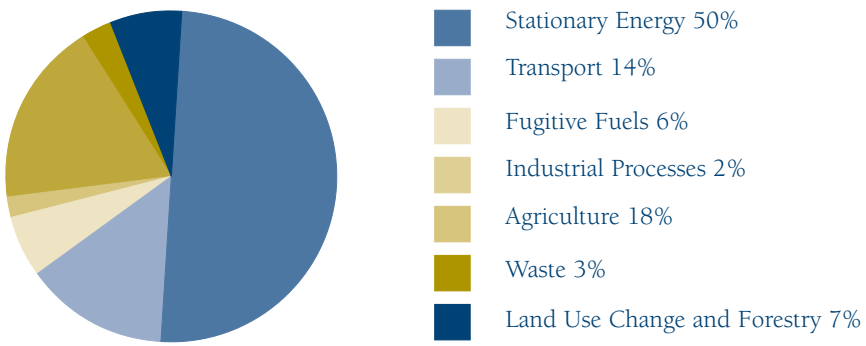
Between 1990 and 2000 all sectors were net emitters. Table 3.1 summarises emissions and changes since 1990. Greater detail of subsectors is given in Table 3.8.

Table 3.1 Net Greenhouse gas emissions and removals by sector, 1990 to 2000 (Mt CO_2-e)

Sector	1990 Mt CO_2-e	2000 Mt CO_2-e	Change Mt CO_2-e	Change %
Energy	298.7	371.8	73.1	24.5
Stationary Energy	*208.5*	*264.0*	*55.4*	*26.6*
Transport	*61.5*	*76.3*	*14.9*	*24.2*
Fugitive	*28.8*	*31.5*	*2.8*	*9.6*
Industrial Processes	12.0	10.3	-1.7	-14.3
Agriculture	91.3	98.4	7.1	7.8
Land Use Change & Forestry	85.9	38.0	-47.9	-55.8[a]
Waste	15.3	16.7	1.4	9.2
Total net national emissions	**503.3**	**535.3**	**32.0**	**6.3[a]**

(a) This does not equate to Kyoto target accounting. Using the Kyoto target methods, growth in national emissions between 1990 and 2000 is 5%.

Figure 3.1 Contribution to total CO_2-equivalent emissions by sector, 2000

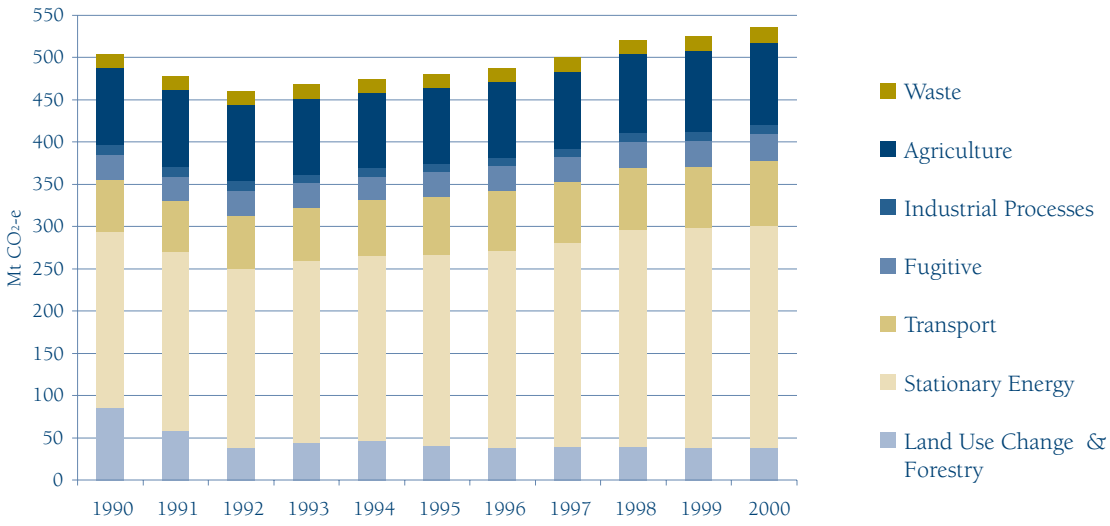


Following the IPCC Guidelines, fuels used by international transport (international aviation and marine bunkers) are reported separately from the national inventory. In 2000, bunker fuels supplied in Australia for international transport generated 10.3 Mt CO_2-e.

Changes in emissions since 1990 (UNFCCC accounting)

The largest percentage increases in net emissions since 1990 have been in the Stationary Energy (26.6%) and Transport (24.2%) sectors. These increases reflect a 12.3% increase in Australia's population and a 39.9% increase in Gross Domestic Product (GDP) during the same period. Emissions per GDP declined by 24% during the same period. Smaller increases occurred in the Fugitive, Waste and Agriculture sectors. Emissions from Industrial Processes decreased by 14.3%. Net Land Use Change and Forestry emissions decreased by 55.8% between 1990 and 2000.

Figure 3.2 Net CO_2-equivalent emissions by sector, 1990 to 2000



EMISSIONS BY GREENHOUSE GAS TYPE (UNFCCC accounting)

Carbon dioxide makes the largest contribution to Australia's net emissions, accounting for 71.0% of all emissions in 2000 compared with 70.7% in 1990.

Methane (CH_4) accounts for 22.1% of total (CO_2-e) emissions in 2000, slightly less than its share in 1990.

The share of nitrous dioxide (N_2O) was 6.0% in 2000, 1.4% higher than in 1990.

Emission of perfluorocarbons (PFCs) declined by more than 76% between 1990 and 2000. A detailed breakdown of the emissions contributions of the direct greenhouse gases for 1990 and 2000 is provided in Table 3.2.

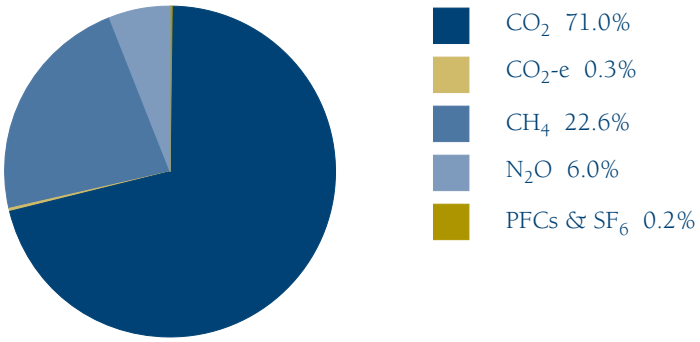
Table 3.2 Net greenhouse gas emissions and changes by gas, 1990 to 2000

Greenhouse Gases	1990 Mt CO_2-e	2000 Mt CO_2-e	1990 % of Total	2000 % of Total	Changes Mt	Change in emissions %
CO_2	356.0	379.9	70.7	71.0	23.9	6.7
CH_4	118.9	121.1	23.6	22.6	2.2	1.9
N_2O	23.2	31.9	4.6	6.0	8.7	37.4
PFCs and SF_6	4.1	1.0	0.8	0.2	-3.1	-75.6
CO_2-e[(a)]	1.2	1.5	0.2	0.3	0.3	25
Total CO_2-e	**503.3**	**535.3**	**100.0%**	**100.0%**	**32.0**	**6.3[(b)]**

(a) Includes confidential CO_2 and N_2O emissions from the Industrial Processes source categories nitric acid and ammonia production.

(b) According to accounting provisions applying to the 108% Kyoto target, the change in emissions between 1990 and 2000 is 5%.

Figure 3.3 Contribution to total net CO_2-equivalent emissions by gas, 2000



Carbon dioxide

The majority of CO_2 emissions in Australia arise from the combustion of fossil fuels. CO_2 emissions from energy-related sources totalled 339.2 Mt in 2000 of which stationary energy accounted for about 77% and transport around 21%.

The largest single contributor to CO_2 emissions was electricity generation (which relies mainly on coal), followed by road transport.

In 2000, emissions from land use change were 60.8 Mt. This was partially offset by the uptake of carbon through the growth of forests and other woody biomass and through pasture improvement. These sinks accounted for about 27.9 Mt in 2000. This resulted in net CO_2 emissions of 32.8 Mt.

The overall increase in net CO_2 emissions from 1990 to 2000 was almost 7%. CO_2 emissions from the Energy sector were more than 25% higher in 2000 than in 1990.

Emissions from electricity generation are approximately 35.5% higher in 2000 than in 1990 due to increased demand for energy. Emissions from the Transport sector increased by 21.1% over the same period. With the exception of domestic navigation, CO_2 emissions for all areas of the Transport Sector increased between 1990 and 2000. In contrast, Land Use Change and Forestry emissions were 58% lower in 2000 than in 1990.

Table 3.3 Total CO_2 emissions and removals by sector, 1990 to 2000 (UNFCCC accounting)

Sector	1990 Mt	2000 Mt	Change Mt	Change %
Energy	271.2	339.2	68	25.1
Stationary Energy	*206.0*	*261.0*	*55*	*26.1*
Transport	*59.2*	*71.7*	*12.5*	*21.1*
Fugitive	*6.0*	*6.5*	*0.5*	*8.5*
Industrial Processes	6.7	7.8	1.1	16.5
Land Use Change & Forestry	78.1	32.8	-45.3	-58.0
Total net emissions	**356.0**	**379.8**	**23.8**	**6.7**

Methane

Australia's methane (CH_4) emissions amounted to 5.7 Mt in 2000, equivalent to 121.1 Mt CO_2. This is about 1.8% more than in 1990.

The Agriculture sector accounted for around 60.3% of the national 2000 CH_4 emissions. Livestock contributed 87% of the Agriculture sector CH_4 emissions through enteric fermentation and the decomposition of animal wastes. Smaller quantities of CH_4 were generated in rice cultivation, through burning of savannas to increase grass production and in the field burning of crop residues.

Livestock emissions were about 4.3% lower in 2000 than in 1990. The decline is the result of a decline in sheep numbers due largely to a downturn in the wool industry. There has been some offsetting increases in cattle numbers and the area of cropping.

Fugitive emissions from fuels accounted for about 21% of national CH_4 emissions. About 74% of these fugitive emissions came from the mining of coal for local use and for export. Fugitive CH_4 emissions have increased about 10% between 1990 and 2000, due to increased coal production. Notably, emissions have not increased as fast as coal production as there has been a shift to the less CH_4 intensive open cut mines.

Another significant contributor to CH_4 emissions is the Waste sector, which accounted for 13.3% of the national total. More than 91% of the CH_4 emissions for the Waste sector were generated from anaerobic decomposition of organic matter in landfills. Emissions of CH_4 from the Waste sector were about 8.9% higher in 2000 than in 1990.

Table 3.4 Total CH_4 emissions by sector, 1990 to 2000

Sector	1990 Mt	2000 Mt	Change Mt	Change %
Energy	1.194	1.306	0.112	9.4
Stationary Energy	*0.081*	*0.091*	*0.010*	*11.8*
Transport	*0.029*	*0.024*	*-0.005*	*-17.1*
Fugitive	*1.084*	*1.192*	*0.107*	*9.9*
Industrial Processes	0.003	0.003	0.000	0.7
Agriculture	3.435	3.474	0.039	1.1
Land Use Change & Forestry	0.323	0.213	-0.111	-34.2
Waste	0.705	0.768	0.063	9.0
Total emissions	**5.660**	**5.504**	**0.104**	**1.8**

Nitrous oxide

Australia's nitrous oxide (N_2O) emissions were 0.1 Mt in 2000, equivalent to 31.9 Mt CO_2. This was about 37.6% more than in 1990.

Agriculture accounted for 79.9% of national N_2O emissions. Most of this N_2O was produced from the application of fertiliser and animal wastes to agricultural soils. Burning of savannas to increase grass production, field burning of agricultural residues and manure management accounted for the balance. Agriculture Sector N_2O emissions have increased by 33% between 1990 and 2000 due to increasing intensification of the livestock industries and increased application of fertilisers.

The Transport sector accounted for 13.0% of the N_2O inventory. Emissions of N_2O from transport have more than doubled between 1990 and 2000 with additional vehicles using three-way catalytic converters. Cars with three-way catalytic converters emit about 154% more N_2O than those without pollution controls.

Table 3.5 Total N_2O emissions by sector, 1990 to 2000

Sector	1990 Mt	2000 Mt	Change Mt	Change %
Energy	0.0080	0.0167	0.0088	110.2
Stationary Energy	*0.0026*	*0.0033*	*0.0007*	*28.4*
Transport	*0.0053*	*0.0133*	*0.0080*	*153.3*
Fugitive	*0.0001*	*0.0001*	*0.000*	*-25.4*
Industrial Processes [a]	C	C		
Agriculture	0.0620	0.0822	0.0202	32.6
Land Use Change & Forestry	0.0033	0.0022	-0.0010	-32.1
Waste	0.0018	0.0017	0.0002	12.3
Total emissions	**0.0748**	**0.1029**	**0.0281**	**37.6**

(a) N_20 emissions from nitric acid production are confidential

Synthetic gases

Perfluorocarbons (PFCs) are not major contributors to total CO_2-e emissions. The best available data are for PFCs generated in the aluminium production process, which represents the bulk of PFC emissions in Australia. Improvements in process control and monitoring have resulted in emissions declining from about 4.1 Mt CO_2-e in 1990 to under 1.0 Mt CO_2-e in 2000, a fall of about 76%.

Hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) are not reported in the 2000 Inventory. The AGO is working towards ensuring better data sources for the range of synthetic gases used in the electricity supply industry and the Montreal Protocol industries.

Indirect greenhouse gases

Emissions of the indirect greenhouse gases, carbon monoxide (CO), oxides of nitrogen (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2), are also estimated. As global warming potentials are not available for these gases, it is not possible to include them in the national aggregate emissions when expressed as CO_2-e. Emissions of indirect greenhouse gases are summarised in Table 3.6. The gases are emitted from some industrial processes and the burning of fossil fuels and biomass.

Table 3.6 Total emission of indirect greenhouse gases 1990 to 2000

	1990 Gg	2000 Gg	Change 1990-2000 %
NO_x	2311.5	2878.0	24.5
CO	22557.9	24850.4	10.2
NMVOC	2534.1	2577.5	1.7
SO_2	1623.6	2389.0	47.1

METHODOLOGY

Changes since Second National Communication

There have been a number of changes to the Australian Inventory methodology and improvements in input data since Australia's Second National Communication, submitted in 1997. The emissions calculated for 1990 are about 31% higher than the 1990 emissions previously reported.

The reasons for the emission recalculations are as follows:

- incorporation of additional gases and source categories due to the revision of the IPCC guidelines;
- improvements in methodology;
- inclusion of land use change emissions in the national total. These emissions were previously reported separately from the national total due to high uncertainties in absolute emissions and trends;
- revision of data values (i.e. better data has been obtained, or estimated values have been over-written with actual data);
- revision of data series; and
- the correction of previous computation errors.

Methodology paths can be followed by consulting the methodology workbooks and the methodology supplements.

Reporting, averaging and adjustments

For the large part, the Australian Inventory is compiled on an Australian financial (statistical) year basis, which runs from July to June. For example, 2000 means the period from 1 July 1999 to 30 June 2000.

Emissions from livestock, agriculture, land use change and waste embody some data for more than a single year, either through algorithms that relate emissions in a given year to activity in previous years or through the averaging of annual inventory data. For example, emission estimates for the Agriculture sector represent a three year average. In the 2000 Inventory, agricultural emissions are based on two-year averages only, since data for 2001 are not yet available.

There are no adjustments to sectoral emissions estimates for climate or any other factors.

Uncertainty

Uncertainties in estimation of greenhouse gas emissions in some areas of the Inventory arise from three main sources:

- paucity and inadequate representation of the basic input data;
- inadequate understanding of the basic processes resulting in greenhouse gas emissions and sinks; and
- application of average conditions across very different environments.

Uncertainties are estimated using a mix of expert judgement and more rigorous quantitative analysis. Quantitative uncertainty assessments are made using the Monte Carlo techniques recommended by the IPCC Good Practice Guide.

Uncertainty in the emissions estimates for each sector can be summarised as follows:

- Fuel combustion – <10% for estimates of CO2 and >20% for other gases;
- Fugitive emissions – 10 to 20%;
- Industrial Processes – < 10%;
- Agriculture – <20% for livestock emission and >80% for other subsectors;
- Land Use Change and Forestry – <20%; and
- Waste – >50%.

METHODOLOGY WORKBOOKS

AGO (2002) *Greenhouse Gas Emissions from Land Use Change in Australia: an integrated application of the National Carbon Accounting System*. Australian Greenhouse Office, Canberra

NGGIC (1996) *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks*. National Greenhouse Gas Inventory Committee, Canberra.

Workbook for Fuel Combustion Activities (Stationary Sources). National Greenhouse Gas Inventory Committee, Workbook 1.1 1996, Canberra.

Workbook for Fugitive Fuel Emissions (Fuel Production, Transmission, Storage and Distribution). National Greenhouse Gas Inventory Committee, Workbook 2.1 1996, Canberra.

Workbook for Transport (Mobile Sources) National Greenhouse Gas Inventory Committee, Workbook 3.1 1996, Canberra.

Workbook for Non-Carbon Dioxide Gases from the Biosphere. National Greenhouse Gas Inventory Committee, Workbook 5.1 1996, Canberra.

Workbook for Livestock. National Greenhouse Gas Inventory Committee, Workbook 6.1 1996, Canberra.

Workbook for Industrial Processes and Solvents and Other Product Use. National Greenhouse Gas Inventory Committee, Workbook 7.1 1996, Canberra.

Workbook for Waste. National Greenhouse Gas Inventory Committee, Workbook 8.1 1996, Canberra.

NGGIC (1997a) *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Workbook for Carbon Dioxide from the Biosphere*. National Greenhouse Gas Inventory Committee, Workbook 4.2 1997, Canberra.

Supplementary methodologies

NGGIC (1997b) *National Greenhouse Gas Inventory 1995*. National Greenhouse Gas Inventory Committee, Canberra.

NGGIC (1998) *National Greenhouse Gas Inventory 1996*. National Greenhouse Gas Inventory Committee, Canberra.

NGGIC (1999) *National Greenhouse Gas Inventory 1997*. National Greenhouse Gas Inventory Committee, Canberra.

AGO (2000) *National Greenhouse Gas Inventory 1998*. Australian Greenhouse Office, Canberra.

AGO (2001) *National Greenhouse Gas Inventory 1999*. Australian Greenhouse Office, Canberra.

AGO (2002) *National Greenhouse Gas Inventory 2000*. Australian Greenhouse Office, Canberra.

Table 3.7 Greenhouse gas emissions by subsector, 2000 (CO_2-equivalent)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)	**379,852.36**	**121,054.39**	**31,905.57**	**0.00**	**973.12**	**2.39**	**535,252.41**
1. Energy	**339,203.28**	**27,429.38**	**5,192.36**				**371,825.02**
A. Fuel Combustion (Sectoral Approach)	332,716.03	2,406.08	5,165.74				340,287.85
1. Energy Industries	191,289.69	167.30	610.69				192,067.67
2. Manufacturing Industries and Construction	52,128.10	54.01	274.08				52,456.19
3. Transport	71,692.91	503.59	4,138.21				76,334.72
4. Other Sectors	15,208.21	1,679.71	130.33				17,018.25
5. Other	2,397.12	1.46	12.44				2,411.02
B. Fugitive Emissions from Fuels	6,487.25	25,023.30	26.61				31,537.17
1. Solid Fuels	NE	18,411.31	NE				18,411.31
2. Oil and Natural Gas	6,487.25	6,612.00	26.61				13,125.86
2. Industrial Processes	**7,786.75**	**62.16**	**C**	**NE**	**973.12**	**2.39**	**10,289.00**
A. Mineral Products	5,208.09	NA	NA				5,208.09
B. Chemical Industry[1]	C	NE	C	NA	NA	NA	1,464.59
C. Metal Production	2,578.66	62.16	NE		973.12	2.39	3,616.32
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NO	NO	NO	NO
F. Consumption of Halocarbons and SF_6				NE	NE	NE	NE
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**NA**		**NE**				**NE**
4. Agriculture	**NA**	**72,956.42**	**25,483.94**				**98,440.36**
A. Enteric Fermentation		61,346.19					61,346.19
B. Manure Management		1,765.33	615.36				2,380.69
C. Rice Cultivation		738.61					738.61
D. Agricultural Soils	NA	NE	18,076.61				18,076.61
E. Prescribed Burning of Savannas		8,843.68	6,682.00				15,525.68
F. Field Burning of Agricultural Residues		262.61	109.97				372.58
G. Other		NA	NA				NA
5. Land-Use Change and Forestry	**32,846.03**	**4,470.13**	**687.55**				**38,003.71**
6 Waste	**16.30**	**16,136.29**	**541.73**				**16,694.33**
A. Solid Waste Disposal on Land	NE	14,811.63					14,811.63
B. Wastewater Handling		1,324.67	541.73				1,866.40
C. Waste Incineration	16.30	NE	NE				16.30
D. Other	NA	NA	NA				NA
7 Other (*please specify*)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
NA	NA	NA	NA	NA	NA	NA	NA
Memo Items:							
International Bunkers	**10,197.09**	**3.15**	**92.88**				**10,293.13**
Aviation	7,648.31	0.57	71.05				7,719.93
Marine	2,548.78	2.59	21.83				2,573.20
Multilateral Operations	**NE**	**NE**	**NE**				**NE**
CO_2 Emissions from Biomass	**20,952.86**						**20,952.86**

1. Speciated emissions from Ammonia Production and Nitric Acid Production are Confidential. These emissions are reported in Summary Table 2 and Table 10s5 as CO_2-e emissions. The total emissions from 2B. Chemical Industry are 1464.59 Gg CO_2-e.

Table 3.7 Greenhouse gas emissions by subsector, 2000 (CO_2-equivalent) – continued

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	**CO_2 equivalent (Gg)**					
A. Changes in Forest and Other Woody Biomass Stocks	54,219.62	-77,944.59	-23,724.96			-23,724.96
B. Forest and Grassland Conversion	60,794.53	0.00	60,794.53	3,527.30	430.26	64,752.09
C. Abandonment of Managed Lands	NA	NA	NA			NA
D. CO_2 Emissions and Removals from Soil	NE	-4,223.54	-4,223.54			-4,223.54
E. Other	NA	NA	NA	942.84	257.29	1,200.13
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	115,014.16	-82,168.13	32,846.03	4,470.13	687.55	38,003.71

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	497,248.70
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	535,252.41

(a) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.

Table 3.8 Trends in greenhouse gas emissions by sector, 1990 to 2000 (CO_2-equivalent)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	(Gg)										
1. Energy	**298,726.89**	**300,463.64**	**304,506.57**	**307,134.88**	**312,094.50**	**324,381.22**	**334,168.78**	**342,522.14**	**360,460.95**	**363,648.43**	**371,825.02**
A. Fuel Combustion (Sectoral Approach)	269,962.64	272,453.40	275,364.43	278,845.61	284,537.89	294,740.04	304,775.02	313,300.69	329,292.93	333,503.42	340,287.85
1. Energy Industries	142,283.89	145,792.61	149,020.09	150,296.69	151,362.82	157,335.68	163,881.70	170,033.76	185,479.71	188,033.34	192,067.67
2. Manufacturing Industries and Construction	50,301.61	49,670.90	47,468.45	47,686.68	50,278.09	51,154.05	52,165.41	51,769.20	51,705.88	52,114.30	52,456.19
3. Transport	61,459.28	60,991.47	62,792.63	63,792.37	65,608.74	68,372.92	70,614.43	72,388.35	72,603.14	73,906.37	76,334.72
4. Other Sectors	14,227.80	14,347.39	14,733.58	15,267.33	15,404.64	15,878.88	15,971.06	16,910.43	17,088.85	17,111.82	17,018.25
5. Other	1,690.06	1,651.03	1,349.68	1,802.54	1,883.60	1,998.51	2,142.42	2,198.96	2,415.34	2,337.58	2,411.02
B. Fugitive Emissions from Fuels	28,764.25	28,010.24	29,142.15	28,289.27	27,556.61	29,641.18	29,393.76	29,221.44	31,168.02	30,145.01	31,537.17
1. Solid Fuel	15,816.36	15,979.04	16,619.63	16,611.41	16,084.42	16,711.94	17,431.48	17,005.23	18,721.53	18,362.03	18,411.31
2. Oil and Natural Gas	12,947.88	12,031.20	12,522.52	11,677.86	11,472.19	12,929.24	11,962.29	12,216.22	12,446.49	11,782.98	13,125.86
2. Industrial Processes	**12,009.61**	**11,665.14**	**11,526.00**	**10,771.81**	**10,688.79**	**9,696.30**	**9,848.56**	**9,678.46**	**10,879.45**	**10,408.74**	**10,289.00**
A. Mineral Products	4,858.20	4,551.14	4,373.14	4,570.87	5,294.76	5,069.60	5,151.98	5,083.05	5,477.55	5,413.30	5,208.09
B. Chemical Industry[1]	C	C	C	C	C	C	C	C	C	C	C
C. Metal Production	5,981.25	5,980.30	5,971.12	5,014.87	4,096.27	3,335.16	3,337.38	3,260.85	3,900.11	3,577.35	3,616.32
D. Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Production of Halocarbons and SF_6											
F. Consumption of Halocarbons and SF_6											
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
4. Agriculture	**91,349.30**	**91,642.27**	**90,238.66**	**89,897.05**	**89,177.39**	**89,295.70**	**89,341.48**	**91,416.78**	**92,440.01**	**95,180.77**	**98,440.35**
A. Enteric Fermentation	64,381.68	64,536.40	63,447.84	62,212.30	60,960.78	60,393.82	60,164.32	60,407.77	60,361.37	61,006.13	61,346.19
B. Manure Management	1,868.43	1,903.72	1,975.28	2,086.36	2,165.92	2,157.34	2,148.20	2,195.44	2,308.85	2,365.26	2,380.69
C. Rice Cultivation	490.50	523.78	536.08	598.63	606.24	648.74	702.28	722.05	724.47	670.72	738.61
D. Agricultural Soils	14,669.16	14,818.23	14,737.55	15,027.95	15,143.49	14,873.42	14,725.64	15,649.24	16,509.10	17,404.05	18,076.61
E. Prescribed Burning of Savannas	9,667.99	9,598.03	9,275.25	9,685.99	10,015.91	10,925.88	11,282.61	12,085.87	12,165.26	13,368.67	15,525.68
F. Field Burning of Agricultural Residues	271.55	262.12	266.65	285.82	285.05	296.50	318.43	356.42	370.96	365.94	372.58
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land-Use Change and Forestry	**85,927.55**	**58,406.59**	**38,010.19**	**43,847.86**	**46,461.59**	**40,762.33**	**37,833.27**	**39,526.08**	**39,910.23**	**38,299.42**	**38,003.71**
A. Changes in Forest and Other Woody Biomass Stocks	-24,598.42	-24,084.18	-24,543.87	-24,154.58	-23,173.16	-22,380.22	-22,431.63	-22,517.35	-22,710.40	-23,656.64	-23,724.96
B. Forest and Grassland Conversion	113,200.74	85,116.61	65,270.43	70,745.50	72,449.25	65,875.00	63,048.61	64,748.23	65,336.50	64,752.09	64,752.09
C. Abandonment of Managed Lands	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. CO2 Emissions and Removals from Soil	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54	-4,223.54
E. Other	1,548.77	1,597.69	1,507.17	1,480.49	1,409.04	1,491.09	1,439.84	1,518.75	1,507.67	1,427.52	1,200.13
6. Waste	**15,285.90**	**15,621.73**	**15,804.24**	**16,140.52**	**16,083.95**	**15,769.80**	**15,882.01**	**16,123.15**	**15,955.37**	**16,455.74**	**16,694.33**
A. Solid Waste Disposal on Land	13,623.32	13,937.81	14,099.77	14,419.29	14,344.40	13,992.28	14,084.51	14,301.48	14,113.45	14,593.29	14,811.63
B. Waste-water Handling	1,662.58	1,683.92	1,704.47	1,721.23	1,739.55	1,760.69	1,783.97	1,804.73	1,824.80	1,844.96	1,866.40
C. Waste Incineration	NE	NE	NE	NE	NE	16.83	13.53	16.94	17.13	17.49	16.30
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other (*please specify*)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Emissions/Removals with LUCF	**503,299.25**	**477,799.37**	**460,085.66**	**467,792.12**	**474,506.22**	**479,905.34**	**487,074.10**	**499,266.61**	**519,646.02**	**523,993.10**	**535,252.41**
Total Emissions without LUCF	**417,371.70**	**419,392.78**	**422,075.48**	**423,944.26**	**428,044.63**	**439,143.01**	**449,240.83**	**459,740.53**	**479,735.79**	**485,693.68**	**497,248.70**
Memo Items:											
International Bunkers	**6,461.40**	**6,438.86**	**6,646.42**	**7,053.58**	**7,308.07**	**8,613.12**	**9,115.69**	**9,105.41**	**9,562.31**	**9,809.75**	**10,293.13**
Aviation	4,385.62	4,562.49	4,840.41	5,247.80	5,403.82	5,912.32	6,370.59	6,561.81	7,300.53	7,336.08	7,719.93
Marine	2,075.79	1,876.37	1,806.01	1,805.78	1,904.26	2,700.80	2,745.10	2,543.60	2,261.79	2,473.66	2,573.20
Multilateral Operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**16,514.85**	**16,641.90**	**15,141.52**	**16,799.68**	**17,618.70**	**18,447.90**	**18,437.02**	**20,275.50**	**20,492.97**	**20,145.07**	**20,952.86**

1. Speciated emissions from Ammonia Production and Nitric Acid Production are **Confidential**. These emissions are reported in Table 10s5 as CO_2-e emissions from sectors where data are confidential.

Table 3.9 Trends in greenhouse gas emissions by gas, 1990 to 2000 (CO_2-equivalent)

GREENHOUSE GAS EMISSIONS	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	CO_2 equivalent (Gg)											
Net CO_2 emissions/removals	355,991.12	355,991.12	331,474.91	314,756.15	323,463.38	331,883.01	336,264.66	342,962.70	352,140.13	369,689.95	372,299.17	379,852.36
CO_2 emissions (without LUCF)	277,867.12	277,867.12	279,599.32	282,038.25	285,479.67	291,431.35	301,101.02	310,585.69	318,222.19	334,904.17	339,384.82	347,006.33
Confidential emissions reported as CO2-e[1]	1,170.16	1,170.16	1,133.70	1,181.74	1,186.07	1,297.75	1,291.54	1,359.20	1,334.56	1,501.79	1,418.09	1,464.59
CH_4	118,862.87	118,862.87	117,653.29	116,534.40	115,682.83	114,301.80	115,544.42	115,783.58	117,438.92	118,595.74	119,189.33	121,054.38
N2O	23,182.32	23,182.32	23,441.37	23,523.90	24,424.40	25,037.30	25,437.00	25,667.93	27,224.79	28,388.27	30,077.11	31,905.57
HFCs	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PFCs	4,092.78	4,092.78	4,096.10	4,089.47	3,035.44	1,986.34	1,367.71	1,292.09	1,122.24	1,466.61	1,005.82	973.12
SF_6	NE	NE	NE	NE	NE	NE	NE	8.60	5.98	3.66	3.59	2.39
Total (with net CO_2 emissions/removals)	**503,299.25**	**503,299.25**	**477,799.37**	**460,085.66**	**467,792.12**	**474,506.22**	**479,905.34**	**487,074.10**	**499,266.61**	**519,646.02**	**523,993.10**	**535,252.41**
Total (without CO_2 from LUCF)	**425,175.25**	**425,175.25**	**425,923.78**	**427,367.76**	**429,808.41**	**434,054.55**	**444,741.70**	**454,697.10**	**465,348.67**	**484,860.24**	**491,078.75**	**502,406.38**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	CO_2 equivalent (Gg)											
1. Energy	298,726.89	298,726.89	300,463.64	304,506.57	307,134.88	312,094.50	324,381.22	334,168.78	342,522.14	360,460.95	363,648.43	371,825.02
2. Industrial Processes	12,009.61	12,009.61	11,665.14	11,526.00	10,771.81	10,688.79	9,696.30	9,848.56	9,678.46	10,879.45	10,408.74	10,289.00
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Agriculture	91,349.30	91,349.30	91,642.27	90,238.66	89,897.05	89,177.39	89,295.70	89,341.48	91,416.78	92,440.01	95,180.77	98,440.35
5. Land-Use Change and Forestry	85,927.55	85,927.55	58,406.59	38,010.19	43,847.86	46,461.59	40,762.33	37,833.27	39,526.08	39,910.23	38,299.42	38,003.71
6. Waste	15,285.90	15,285.90	15,621.73	15,804.24	16,140.52	16,083.95	15,769.80	15,882.01	16,123.15	15,955.37	16,455.74	16,694.33
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1. Includes confidential emissions of CO_2 from Ammonia Production (2B1) and N_2O from Nitric Acid Production (2B2).

CHAPTER FOUR
POLICIES AND MEASURES

POLICY-MAKING PROCESS

Australia's *Second National Communication* under the United Nations Framework Convention on Climate Change (UNFCCC), submitted in November 1997, set out progress on implementation of policies and measures to reduce greenhouse gas emissions, including details of substantial greenhouse measures under the Prime Minister's $180 million Safeguarding the Future package of measures announced in 1997. Since then, significant progress has been made in implementing these and a range of other major policies and measures (including Commonwealth programs announced in 1999 costing up to $796 million under Measures for a Better Environment) to place Australia's greenhouse response efforts, proportionate to its size, at the forefront of global action.

The National Greenhouse Strategy (NGS) provides the strategic framework for advancing Australia's domestic greenhouse response. Launched in 1998, the NGS extended substantially the program of action begun by the 1992 National Greenhouse Response Strategy and includes the Prime Minister's Safeguarding the Future package. The NGS was developed and agreed by Commonwealth and State and Territory governments, with input from local governments, industry and the community. In endorsing the NGS, the Commonwealth, States and Territories have indicated their ongoing commitment to responding effectively to the global challenge of climate change.

The NGS articulates the framework for a coordinated and collaborative approach by all levels of government in Australia. It groups some 86 individual measures into eight sectoral 'modules' which are directed toward the achievement of three overarching goals:

- fostering knowledge and understanding of greenhouse issues;
- limiting greenhouse gas emissions; and
- laying the foundations for adaptation to climate change.

The priority in the first three years of the strategy has necessarily been emissions abatement. The Commonwealth Government, through the framework of the NGS and through the additional complementary measures under Measures for a Better Environment, has committed almost $1 billion to its greenhouse response. This level of Commonwealth expenditure on a broad range of policies and measures, coupled with the commitments made by States and Territories, places Australia among the leading nations addressing climate change and makes an important contribution to enabling Australia to meet its international commitments.

The Commonwealth Government decided in July 2002 to commence development of a forward strategy on climate change that will position Australia for a longer term response to climate change. The Government also decided not to ratify the Kyoto Protocol unless and until it is demonstrated that it is in the national interest to do so. The longer term focus will however be combined with a shorter term focus upon the development and investment of funding in domestic programs to meet Australia's target under the Kyoto Protocol of limiting greenhouse emissions to 108% of 1990 emissions levels over the period 2008 – 2012. As part of the way forward, a government-business dialogue will take place to inform the development of Australia's forward greenhouse strategy. The Government will also work closely with States and Territories to ensure a coherent national approach.

This chapter sets out details of Australia's policies and measures aimed at limiting and reducing greenhouse gas emissions. Under the NGS, the Commonwealth Government has responsibility for policies and measures across all eight NGS modules, with States and Territories taking on key responsibilities in the areas of energy policy, land use change, transport planning and waste management. These measures reflect the full range of policy approaches, from voluntary action and strategic investment to regulation and market measures.

The overview of policies and measures is organised according to sector, with specific sub-references to the individual greenhouse gases limited or reduced by a policy or measure or collection of policies and measures. A summary of the policies and measures, including quantitative estimates of abatement from these policies and measures, is presented in tabular form in Table 4.1 at the end of this chapter.

Integrated into the NGS implementation framework are a number of mechanisms for the effective monitoring and reporting of the policies and measures pursued by the various levels of government.

- Implementation plans on individual policies and measures are prepared under the NGS by the Commonwealth, States and Territories. These plans are available online at **http://ngs.greenhouse.gov.au**.
- Regular reports are required on progress in implementing the NGS. The *National Greenhouse Strategy 2000 Progress Report* can be viewed online at **http://www.greenhouse.gov.au/pubs/ngs/progress_report2000.pdf.**
- Emission accounting mechanisms such as the annual compilation of the National Greenhouse Gas Inventory (**http://www.greenhouse.gov.au/inventory/index.html**) and the National Carbon Accounting System (**http://www.greenhouse.gov.au/ncas**) provide a complete accounting capability for sources and sinks of greenhouse gas emissions from Australian land based systems. For further detail on these refer to *Chapter 3 – National Greenhouse Gas Inventory*.
- The development of projections of greenhouse gas emissions is another important mechanism in monitoring policies and measures. Refer to Table 4.1 in this chapter and *Chapter 5 – Projections* for further detail.
- Detailed performance indicators have also been developed by the Commonwealth and States and Territories to contribute to estimates of abatement from policies and measures. Regular application of these indicators will assist in assessing the effectiveness of NGS measures, as well as helping identify areas for further attention or review. The performance indicators are available at **http://ngs.greenhouse.gov.au/performance/index.html**.

Implementation of the NGS at the Commonwealth level has required extensive coordination between relevant portfolios, notably the Environment and Heritage, the Industry, Tourism and Resources, and the Agriculture, Fisheries and Forestry portfolios. Implementation of the NGS also requires considerable coordination between the Commonwealth and States and Territories. A High Level Group on Greenhouse (HLGG) of senior officials from the Commonwealth, States and Territories is responsible for managing the implementation, monitoring, review and further development of the NGS. The HLGG reports to the Council of Australian Governments.

NGS measures requiring national coordination are also managed through a number of Commonwealth–State Ministerial Councils, including:

- the Ministerial Council on Natural Resource Management;
- the Ministerial Council on Energy;
- the Australian Transport Council; and
- the Environment Protection and Heritage Council.

POLICIES AND MEASURES AND THEIR EFFECTS

Cross-sectoral

The development of partnerships between government, industry and the wider community to limit greenhouse gas emissions is a vital component of the NGS and is particularly important for the success of policies and measures that cut across a number of greenhouse sectors. The cross-sectoral policies and measures described below reflect the importance of this partnership-based approach.

In accordance with Module 3 of the NGS – *Partnerships for Greenhouse Action: Governments, Industry and the Community* – greenhouse partnerships have been developed by the various levels of governments by working with industry (through measures such as Greenhouse Challenge and the Greenhouse Gas Abatement Program), by fostering broader community engagement (through local government initiatives such as the Cities for Climate Protection™ – Australia and Household Greenhouse Action), and by promoting international greenhouse partnerships (for example, through the International Greenhouse Partnerships Program).

GREENHOUSE GAS ABATEMENT PROGRAM

Greenhouse gases affected

CO_2 / CH_4 / N_2O / HFCs / PFCs / SF_6

The Greenhouse Gas Abatement Program (GGAP) aims to reduce Australia's net greenhouse gas emissions by supporting industry and community activities that are likely to result in substantial emission reductions or substantial sink enhancement, particularly in the first commitment period (2008 – 2012) under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol). $400 million has been allocated to the Program between 2000/2001 and 2003/2004. This measure is a key part of the Measures for a Better Environment package announced by the Commonwealth Government in May 1999.

GGAP is designed to deliver cost-effective, large scale and sustained abatement that is not funded by other existing programs. Priority is given to projects that deliver abatement exceeding 250 000 tonnes of carbon dioxide equivalent (CO_2-e) per annum. In keeping with the Commonwealth Government's commitment to reduce greenhouse gas emissions through cost-effective actions that minimise the burden for business and the community, GGAP seeks out projects with a low cost for each tonne of emissions reduced.

To date the Commonwealth has invested approximately $150 million for a range of projects including energy, transport fuels, mining, industrial processes and agriculture. It is expected that these projects will abate over 26 Mt CO_2-e in the first Kyoto commitment period.

ESTABLISHMENT OF THE AUSTRALIAN GREENHOUSE OFFICE

The Australian Greenhouse Office is the lead Commonwealth agency on greenhouse matters. It was established as part of the Prime Minister's 1997 Safeguarding the Future package. It coordinates Australia's climate change policy, which is developed in a whole-of-government context.

The Australian Greenhouse Office is responsible for the delivery of the nearly $1 billion of Commonwealth policies and measures for greenhouse gas abatement. It works collaboratively with government, industry and the community.

GREENHOUSE CHALLENGE PROGRAM

Greenhouse gases affected

CO_2 / CH_4 / N_2O / HFCs / PFCs / SF_6

The Greenhouse Challenge – launched in 1995 – is a joint initiative between the Commonwealth and industry to abate greenhouse gas emissions. Participating organisations sign agreements with the Government that provide a framework for voluntary actions to abate emissions. As part of the Prime Minister's Safeguarding the Future package, the Greenhouse Challenge program was extended and expanded to allow an even greater uptake by industry. Through the Greenhouse Challenge program, firms are developing inventories of their greenhouse gas emissions, developing action plans to reduce those emissions and reporting on their progress in achieving emissions reductions.

Since Australia's *Second National Communication* in November 1997, the number of companies joining the program has increased from around 200 to over 700. Membership is expected to increase to more than 1 000 by 2005. In addition to increasing overall membership, the program is also increasing its membership in the previously under-represented transport and agriculture sectors, and engaging industry in efforts to reduce emissions of sulphur hexafluoride (SF_6). The Greenhouse Challenge program already has excellent coverage of emissions in some key areas, including 100% coverage of aluminium and cement production, 98% of oil and gas, 98% of the electricity sector and 91% of coal mining.

A 1999 evaluation of the program found that it has been highly effective in achieving greenhouse gas emissions abatement and in building the capacity of both Government and industry to identify, monitor, manage and report greenhouse gas emissions. In 2000, procedures for independent verification of emissions savings of firms were developed and an initial round of independent assessments (35 firms) found that members were reporting in accordance with program guidelines.

GREENHOUSE FRIENDLY PROGRAM

Greenhouse gases affected

CO_2 / CH_4 / N_2O / HFCs / PFCs / SF_6

The Greenhouse Friendly Program is a voluntary certification and labelling initiative applying to products and services. It is designed to engage consumers on climate change issues and greenhouse gas abatement and to broaden the basis for investment in greenhouse gas abatement. The supplier invests in abatement projects to offset the greenhouse emissions produced during the life (from cradle to grave) of the product or service.

All forms of abatement projects are eligible for the program including carbon sequestration activities, but strict criteria apply. All abatement projects must be financially additional, occur within Australia and all offsets used for the program must be retired once certified.

To maintain the credibility of the program, all information related to product emissions and abatement project emission reductions are reviewed and verified by an independent party before certification is awarded by the Australian Greenhouse Office.

EMISSIONS TRADING

Greenhouse gases affected

CO_2 / CH_4 / N_2O / HFCs / PFCs / SF_6

The Commonwealth is examining the feasibility and implications of emissions trading for Australia. Work undertaken to date suggests that emissions trading can provide a variety of benefits in terms of offering a non-prescriptive and cost-effective approach to greenhouse gas abatement, linkage to international trading systems and reliability in achieving an emissions target. But this analysis is far from complete and the evaluation of emissions trading options will be the focus of continuing consultation.

The Commonwealth announced in August 2000 that it would only implement a mandatory domestic emissions trading scheme if the Kyoto Protocol is ratified by Australia, has entered into force and there is an established international emissions trading regime. The Commonwealth's decision does not rule out the subsequent introduction of such a scheme if further analysis demonstrates that this would be in the national interest.

The Australian Greenhouse Office has released a series of four *Emissions Trading Discussion Papers*, as well as two consultancy papers on emissions trading, and has engaged in extensive public consultation on many policy issues associated with the design of a national emissions trading system. The process aims to facilitate increased policy certainty for businesses.

In November 2000, the Government released the public consultation paper, *Encouraging Early Greenhouse Abatement Action*, in which it announced in-principle support for the development of a system that would credit early abatement action occurring within Australia, if there is sufficient demand for access to 'early action credit' and a satisfactory program design could be agreed. These credits would effectively become permits under any future emissions trading scheme. Participation by industry would be on a voluntary basis.

LOCAL GOVERNMENT STRATEGIES – CITIES FOR CLIMATE PROTECTION™

Greenhouse gases affected

CO_2 / CH_4 / N_2O

Through the Cities for Climate Protection™ (CCP™) Program, local councils have the opportunity to draw on international expertise and world best practice in developing effective greenhouse solutions at the local level. This joint initiative of the Australian Greenhouse Office and the International Council for Local Environmental Initiatives. Greenhouse action modules assist CCP™ councils implement effective greenhouse reduction activities in a range of key greenhouse action areas. The strong commitment of urban councils to the program has made the Australian CCP™ Program the fastest growing CCP™ program in the world – with more than 150 member councils representing over 60% of Australia's population, it has more councils as members than any other country.

GREEN ENERGY LEARNING PROJECT (GELP) – CASE STUDY OF NEWCASTLE CITY COUNCIL

GELP is a practical learning program based on the experiences of Newcastle City Council. GELP illustrates how Newcastle has made greenhouse action self funding and helps participants pursue energy efficiency in their own operations. In particular, it addresses the technical, organisational and financial solutions for effective energy management.

By identifying and implementing simple energy efficiency projects throughout its local council operations, Newcastle City Council has managed almost to halve its annual electricity costs since 1995 under a financial loss control program. Central to this success has been energy efficiency funding made available through a revolving energy fund – electricity costs savings from energy conservation projects are funnelled back to fund further energy efficiency projects. Energy efficiency projects have included upgrading air conditioning systems, overhauling lighting systems with central intelligent lighting control and improving building design.

In July 2001 Newcastle City Council launched its innovative climatecam website – the world's first greenhouse gas 'speedometer' **http://www.climatecam.com**. It provides an accurate measuring tool to track the greenhouse gas emissions for the city of Newcastle by providing monthly consumption data and greenhouse gas emissions from a range of sectors, including electricity, gas, water, waste to landfill and transport. By monitoring the city's emissions, climatecam will be able to report on the effectiveness of Newcastle's greenhouse actions.

HOUSEHOLD GREENHOUSE ACTION PROGRAM

Greenhouse gases affected

CO_2 / CH_4 / N_2O

This program facilitates a range of initiatives with individuals and communities to address greenhouse gas emissions from the household sector.

Cool Communities is an Australian Greenhouse Office project, delivered in collaboration with environmental community groups from each State and Territory, which aims to achieve ongoing, significant and measurable household greenhouse gas reductions by providing information and resources to help householders take action on greenhouse. Local facilitators are working with community reference committees comprising influential community leaders across a wide range of sectors. Household and community actions receive awards and recognition.

The Australian Greenhouse Office is also providing financial support to industry, governments and the community to form innovative partnerships to reduce greenhouse gas emissions from households through its Household Greenhouse Action Grants. It reduces residential greenhouse gas emissions in the areas of refrigeration, lighting, heating and cooling and hot water by addressing barriers to the demand for, and effective use of, energy efficient goods and services.

INTERNATIONAL GREENHOUSE PARTNERSHIPS

Greenhouse gases affected

CO_2 / CH_4 / N_2O / HFCs / PFCs / SF_6

As part of the Prime Minister's Safeguarding the Future package, funding was allocated to progress Australian interests in international collaborative projects to reduce greenhouse emissions through the International Greenhouse Partnerships (IGP) Program, and was administered by the IGP Office within the Department of Industry, Tourism and Resources. This program has helped Australia and Australian industry gain experience

in cooperative greenhouse projects in other countries. Further details of this program are set out in *Chapter 7 – Financial Resources and Transfer of Technology*.

Energy

Total stationary energy emissions for 2000 were estimated to be 264 Mt $C0_2$-e, equal to 49.3% of Australia's total net emissions. This includes emissions from electricity production and petroleum refining, the manufacturing and construction industry, as well as emissions from direct fuel combustion in the residential and commercial sectors.

In recognition of the contribution of energy to Australia's growth in greenhouse gas emissions, Australia's greenhouse response involves significant efforts on both the supply and demand side for energy use. Module 4 of the NGS – *Efficient and Sustainable Energy Use and Supply* – outlines the actions being undertaken in the industrial, commercial and residential sectors to address efficiency and sustainable energy use and suppy. These include:

- reducing the greenhouse intensity of energy supply through the acceleration and monitoring of energy market reform and development of strategies for energy industries to limit greenhouse gas emissions;
- harnessing renewable energy through strategic support and development for the commercialisation of renewable energy technologies; and
- improving end-use energy efficiency through measures such as improvements to the design of commercial and residential buildings, and domestic appliances and commercial and industrial equipment.

ENERGY MARKET REFORM

Greenhouse gases affected

CO_2 / CH_4 / N_2O

Significant progress has been made in implementing energy market reform throughout Australia. In December 1998, a wholesale electricity market was introduced across southern and eastern Australia for the supply and purchase of electricity, combined with open access to transmission and distribution networks. A third party access code for natural gas pipelines has been introduced, enabling producers and consumers to obtain access to gas transmission and distribution pipelines and to ship their gas, interstate, without barriers. This has been a significant factor in attracting new entrants to potential new gas fields and to the retail sector. In the initial stages of the reform process there was an excess supply of electricity in the market. This resulted in relatively depressed market prices, which favoured low cost and high emission incumbents. Accordingly there has been an increase in the greenhouse intensity of energy supply. However, this is not expected to persist over the longer term.

In June 2001, the Council of Australian Governments (COAG) gave further recognition to the need to address greenhouse issues related to energy market reform. COAG agreed to establish a national energy policy framework to guide future decision-making. COAG also agreed to establish a new Ministerial Council on Energy with a priority task to oversee an independent review on strategic issues for Australian energy markets.

One of the priority issues for the independent review will be to assess the relative efficiency and cost effectiveness of options within the energy market to reduce greenhouse gas emissions from the electricity and gas sectors, including the feasibility of a phased introduction of a national system of greenhouse emission reduction benchmarks. The review is expected to be completed by February 2003.

State Governments have also taken specific energy market reform measures. In Western Australia, gas comprises over 50% of the fuel used to generate electricity, most of which is used in gas turbines. The

Western Australia energy market reform process includes progressive reductions of the threshold level for access to the electricity market, providing retail contestability in gas markets, establishing a gas access regulator and expansion of gas infrastructure. An outcome of the reform process has been the increased utilisation of gas in preference to more greenhouse intensive energy sources, including coal, for both electricity generation and other purposes.

On the retail side, under the Queensland Government's Cleaner Energy Strategy electricity retailers will be required from 2005 to source 15% of electricity from gas-fired or renewable energy, with at least 13% from gas-fired sources. The Queensland Government expects the initiative to reduce greenhouse gas emissions by around 20 Mt CO_2-e over ten years.

New South Wales (NSW) guidelines for emissions reductions by electricity retailers incorporate a benchmark of reducing greenhouse gas emissions from electricity supplied to consumers to 5% below the 1989/1990 per capita level by the 2000/2001 reporting year. This builds on a licensing requirement that retailers develop greenhouse strategies to reduce emissions. NSW gas suppliers are also legally required to develop strategies to reduce greenhouse gas emissions and to report annually on their effectiveness. NSW also has a *Demand Management Code of Practice* that requires electricity distributors to consider demand side management options when assessing network constraints. The Australian Capital Territory (ACT) is also reforming regulations and standards for electricity utilities to help achieve emissions targets.

STRATEGIES FOR IMPROVING ENERGY EFFICIENCY

Greenhouse gases affected
CO_2 / CH_4 / N_2O

Generator Efficiency Standards

Generator Efficiency Standards is a Commonwealth best practice program that supports generators using fossil fuels in achieving better performance in their power plants and, as a result, reducing greenhouse gas emissions. The program commenced in 2000 and applies to any power generating plant that uses fossil fuels, whether on-grid, off-grid or self-generating, that meets all of the following criteria:

- 30 MW electrical capacity or above; and
- 50 GWh per annum electrical output or more; and
- a capacity factor of 5% or more in each of the last three years.

The efficiency standards are designed to achieve movement towards best practice in the efficiency of electricity generation using fossil fuels and deliver reductions in the greenhouse gas intensity of energy supply. Under this initiative, the Commonwealth enters into legally binding agreements with generators to achieve agreed emission reduction targets.

It is estimated that the emissions intensity of electricity production will be reduced, saving about 4 Mt of CO_2-e a year, once all the generators have met the required best practice standard determined for each plant.

Energy efficiency and performance standards

Energy efficiency standards for residential and commercial buildings

In July 2000, agreement was reached between the Commonwealth and the State and Territory governments for the introduction of minimum energy performance requirements into the *Building Code of Australia* to increase the energy efficiency of Australian buildings. Through the Australian Building Codes Board, all levels of governments and the building industry are working together to ensure national consistency and effective cooperative action in the national development and adoption of best practice energy efficiency regulation.

The ACT Government has made significant steps in improving the energy efficiency of residential buildings. The *Energy Efficiency Act 1997* requires the energy ratings of dwellings to be disclosed to potential buyers before they are sold, while the *Residential Tenancies (Amendment) Act 1997* requires the disclosure of existing energy ratings to prospective tenants. There is also a mandatory requirement for all new dwellings to achieve a high energy efficiency rating.

Victoria's Energy Smart Commercial Buildings Program aims to improve the capacity of the construction industry to produce low energy buildings and promote the merits of such buildings to the market through a number of initiatives, including support for the development and application of the Australian Greenhouse Rating System, promotion of a building energy brief and model technical specifications, and information dissemination through the Commercial Building Energy Forum. Under Victoria's ResCode, all new multi unit developments will be required to meet a high energy efficiency rating.

In NSW, the Sustainable Energy Development Authority (SEDA) is also undertaking a range of initiatives aimed at improving energy efficiency in homes and commercial buildings. The Energy Smart Homes policy requires all new homes to achieve minimum energy performance requirements. The policy has been adopted by 38 local councils, accounting for 54% of building development applications. The Community Housing Energy program has ensured equitable access to energy efficiency technologies for over 7 800 low-income households. Through SEDA's Energy Smart Business, businesses undertake to implement all identified projects with an internal rate of return of 20% or more. As of July 2001, over $36 million had been invested in energy efficiency projects through the program, with more than $13 million being saved per year in energy costs.

SEDA has also developed a Building Greenhouse Rating that is being rolled out nationally. Memoranda of Understanding have been signed with both the Sustainable Energy Authority of Victoria (SEAV) and the Queensland Environment Protection Authority to implement the scheme in those States.

Energy performance standards for domestic appliances and commercial and industrial equipment

The Australian Greenhouse Office is responsible for coordinating a joint Commonwealth, State and Territory government program that gives effect to NGS objectives to improve the energy efficiency of domestic appliances and commercial and industrial equipment. In 2000, the National Appliance and Equipment Energy Efficiency Program was projected to result in a benefit of $31 per tonne of CO_2-e and to reduce greenhouse gas emissions by a total of 81 Mt CO_2-e over the period 2000 to 2015. By 2015 the impact of the program is projected to reach 10.9 Mt CO_2-e per annum below business as usual.

The program mandates comparative energy labelling and minimum energy performance standards (MEPS) for domestic appliances, commercial products and industrial equipment. State and Territory regulatory agencies are responsible for administering mandatory energy efficiency labelling and MEPS within their jurisdictions.

The program is also targeting measures to reduce standby energy losses – the energy used by an electrical appliance when not performing its central function. A recent study has revealed that standby energy use accounts for 11.6% of residential electricity consumption (or 5.3 Mt CO_2-e per annum). Australian Governments have adopted a one-watt standby target for all products.

Improving energy efficiency in government operations

The Improving Energy Efficiency in Commonwealth Operations Program, which is jointly administered by the Department of Industry, Tourism and Resources and the Australian Greenhouse Office aims to reduce the energy use and greenhouse gas emissions in Commonwealth Government operations by setting energy intensity targets in a number of end-use categories to be met by 2002/2003. There are also certain mandatory

requirements. Since the first reporting period in 1997/1998 there has been a reduction in reported energy consumption and associated emissions.

State and Territory governments have also introduced energy efficiency programs for government operations. NSW has introduced the Government Energy Management Policy to achieve and sustain reduced greenhouse gas emissions and significant energy cost savings across the NSW public sector. The policy's target is to reduce the total energy consumption of government buildings, where cost-effectively feasible, by 15% of the 1996 level by 2002 and 25% of the 1996 level by 2006, and a commitment of government agencies sourcing electricity through the Government's bulk supply contract to purchase 6% of their electricity in the form of Green Power. Under SEDA's Energy Smart Government Program, NSW Government agencies have invested $14 million into the sustainable energy industry over the last three years and fostered the introduction of energy performance contracting. They are currently saving more than $3.8 million in energy costs and 37 000 tonnes of greenhouse gas emissions every year.

In Victoria, the Government has a commitment to a 15% target for reduction in energy consumption by government departments and agencies and to purchase 5% of electricity in the form of Green Power. SEAV provides support for departments and agencies to save energy in existing and new facilities, including energy management programs, technical advice, staff training, energy usage monitoring software and assistance in the implementation of energy savings projects. Since 1 July 2001, the Queensland Government also purchases 5% of its electricity from renewable sources.

The Northern Territory Government's Energy Management Strategy requires government agencies to commit to energy targets. The strategy also requires procurement decisions to consider energy costs and building energy performance standards, targets and general guidelines to be developed and applied to new building projects. Support for renewable energy, sustainable energy demonstration projects, energy performance contracts and minimum star rating requirements for appliances are all also strategy features.

Energy Efficiency Best Practice and Benchmarking Program

Through its Energy Efficiency Best Practice and Benchmarking (EEBP) Program, the Department of Industry, Tourism and Resources has developed benchmarking studies and strategies in a range of industry sectors. This five-year, voluntary program that commenced in 1998 assists sectors to become sustainable and competitive in the future through the stimulation of continuous and big-step improvements in the efficient use of energy. This is achieved through a focus on innovation and training and the implementation of energy efficiency initiatives identified.

EEBP has partnership activities with a range of industry sectors, including aluminium, beverage, bread-baking, dairy and wine, resource processing and supermarkets, with products and services including training modules, innovation workshops, case studies, information sheets and databases.

Eco-efficiency programs

Environment Australia's Business of Sustainable Development Program includes actions to improve the eco-efficiency of Australian industry. Voluntary eco-efficiency agreements are being developed with industry associations. To date, agreements to promote, demonstrate and monitor improved eco-efficiency practices have been signed with the Housing Industry Association, the Australian Food and Grocery Council and the Australian Chamber of Commerce, as well as a number of State and Territory Chambers of Commerce.

States and Territories are also implementing programs to improve eco-efficiency by industry during production and manufacturing. The Queensland Government, through the Greenhouse Partnership Program,

is working with businesses in the manufacturing, construction and transport industries to identify potential eco-efficiency improvements.

Victoria's Sustainability Partnerships Program focuses on eco-efficiency approaches at the production stage to achieve cost savings and environmental gains through improved energy efficiency and waste management, and reduced product losses, waste disposal and raw material costs.

RENEWABLE ENERGY POLICIES AND MEASURES

Greenhouse gases affected

CO_2 / CH_4 / N_2O

As a major element of its greenhouse response in the energy sector, the Commonwealth, States and Territories are also providing a major boost to the commercialisation and uptake of renewable energy. To complement innovative mandatory renewable energy target legislation, up to $382 million has been made available by the Commonwealth to support the renewable energy industry over the period to 2010.

Mandatory Renewable Energy Target

The Prime Minister announced the introduction of a Mandatory Renewable Energy Target for the uptake of additional renewable energy in power supplies as part of his 1997 Safeguarding the Future package. The target seeks to increase the contribution of renewable energy sources in Australia's electricity mix by 9 500 GWh per year by 2010, enough power to meet the residential electricity needs of around four million people. The fixed target of 9 500 GWh requires a significant expansion of renewable energy capacity in Australia and in 2010 renewable energy is expected to represent around 12% of Australia's total electricity supplies, an increase of more than 50% above 1997 levels of renewable energy generation. The measure, by establishing a guaranteed market for new renewable energy and penalties for non-compliance, is a cornerstone of the Commonwealth's industry development strategy for the renewable energy industry sector.

The *Renewable Energy (Electricity) Act 2000*, that supports the implementation of the Mandatory Renewable Energy Target, was passed by the Commonwealth Parliament in December 2000 and the obligation (liability) and entitlement (eligibility) provisions came into force on 1 April 2001. A separate statutory body, the Office of the Renewable Energy Regulator, administers the Act.

Under the Act, wholesale electricity purchasers are required to purchase increasing amounts of electricity generated from renewable sources. In order to discharge their liability, liable parties must surrender renewable energy certificates to the Renewable Energy Regulator. One renewable energy certificate can be created for each megawatt hour of electricity generated from an eligible renewable energy source in an accredited power station. These certificates can be traded through a market separate to the market for physical energy. The renewable energy certificate represents an additional value for renewable energy which when sold, can increase the competitiveness of renewable-based electricity as compared to cheaper fossil fuel-based electricity. Liable parties not purchasing sufficient renewable energy face financial penalties. Further detail regarding the legislative framework and the Office of Renewable Energy Regulator can be accessed online at **http://www.orer.gov.au**.

National Green Power Accreditation Program

Launched initially in 1997 in NSW by SEDA, the Green Power program was one of the first of its type in the world. Today, the National Green Power Accreditation Program, established in May 2000, is offered nationally through joint collaboration by participating State and Territory government agencies in NSW, Victoria, Queensland, South Australia, Western Australia and the ACT.

Under the Green Power program, customers can elect to pay a premium to their energy retailers for the supply of electricity generated from renewable sources (solar, wind, biomass, hydro and geothermal). Accredited energy suppliers then agree to buy an amount of energy from renewable sources equivalent to the amount nominated by participating consumers and businesses. Ongoing compliance of products is checked regularly via financial and technical status reports provided by the energy supplier and independently audited by SEDA.

Supporting renewable energy industry development activities

The Commonwealth has committed significant funding (up to $382 million between 1998 and 2010) for grant and equity programs to boost the commercialisation of renewable energy technologies, to reduce costs and improve quality and reliability, to deploy renewable energy technologies and to help build the capacity of the renewable energy industry to meet the expected high growth in demand for its goods and services.

A significant investment, of around $65 million of grant funding, has been made in renewable energy technology commercialisation projects to foster the development of the renewable energy industry in Australia. Funding, provided under the Renewable Energy Commercialisation Program and Renewable Energy Showcase, commenced in 1998 and all funds have now been fully committed. The programs support and promote leading edge and strategically important renewable energy projects with strong commercial potential, that are technically proven, demonstrate the potential for large-scale widespread application, offer the prospect of significant abatement of greenhouse gas emissions over the longer term and make a substantial contribution to building the capacity of Australia's renewable energy industry.

Approved projects support innovative renewable energy equipment, technologies, systems and processes such as biomass for energy projects, hot dry rock, inverters and control technology, small hydro, solar thermal, batteries, building-integrated photovoltaics and solar hot water systems.

In June 2000, the Minister for Industry, Tourism and Resources launched the Renewable Energy Action Agenda. The Action Agenda establishes a policy framework to promote growth in a commercially viable and internationally competitive Australian renewable energy industry. The Action Agenda addresses the critical strategic issues of importance to the industry's future development and identifies the actions required to achieve a sustainable and internationally competitive renewable energy industry with annual sales of $4 billion by the year 2010. Many of the initiatives in the Action Agenda are supported by the Industry Development component of the Renewable Energy Commercialisation Program, from which $6 million has been allocated for grants to assist the industry in overcoming barriers to growth. Projects include development of a national training package in renewable energy, quality accreditation for installers of renewable systems, laboratory-testing facilities for quality control of renewable equipment, national resource mapping for bioenergy, and best practice guidelines for development of wind farms.

The Renewable Remote Power Generation Program has been developed by the Australian Greenhouse Office in consultation with State and Territory Governments and industry stakeholders to provide support to increase the use of renewable energy generation in remote parts of Australia that presently rely on diesel for electricity generation. Up to $264 million will be available over the ten-year life of the program from 2001. The program helps in providing an effective electricity supply to remote users and assists the development of the Australian renewable energy industry.

The Renewable Energy Equity Fund, which was announced as part of the 1997 Safeguarding the Future package, is aimed at increasing investment in renewable energy technologies through the provision of equity finance to small innovative renewable energy companies. The Commonwealth is providing approximately $17.7 million of funding to be invested along with private sector funding on a 2:1 basis. Target companies

include companies that are commercialising direct or enabling renewable energy technologies and services, providing there is an innovative development being commercialised.

Under the Photovoltaic Rebate Program, which commenced on 1 January 2000, cash rebates are available to householders and owners of community use buildings who install grid-connected or stand-alone photovoltaic systems. Up to $31 million is available over the life of the program. Several States and Territories have also implemented rebate programs for solar hot water heaters. NSW, Victoria, Queensland, South Australia, Western Australia, Northern Territory and the ACT all have solar hot water rebate programs in place aimed at encouraging consumers to install solar hot water heaters.

A number of States are also implementing programs to boost the commercialisation of renewable energy technology and uptake of renewable energy. In NSW, SEDA has provided funding for commercial or near commercial sustainable energy technologies in order to generate private sector investment. Queensland's Office of Sustainable Energy also assists the commercialisation of renewable energy and energy efficiency technologies through a regular grants program.

In Tasmania, planning is underway for the development of a wind farm in north-west Tasmania and feasibility studies are being carried out into mini hydro construction and hydro plant upgrades to increase the amount of renewable energy available to the electricity market.

The Green Games – Sydney 2000 Olympic Games

The Sydney 2000 Olympic Games' environmental achievements showcased the integration of ecologically sustainable development into the delivery of sporting and Olympic venues and facilities. The Environmental Guidelines for the Sydney 2000 Summer Olympic and Paralympic Games included commitments to energy conservation and the use of renewable energy sources. These commitments were primarily achieved through building design and construction, and transport planning, including the provision of new public transport infrastructure.

As part of the successful green bid to host the Olympics, one of the world's largest solar suburbs was created – the Olympic Village. The Olympic Village generates over 1 million kW of power per year, acting as a clean, green mini power station. It is a good example of how to use resources sustainably. The village uses half the energy and produces half the greenhouse emissions of conventional dwellings through design features and energy efficient appliances, and is fitted with rooftop photovoltaic cells that generate sufficient power to meet household energy demands.

Transport

The transport sector produced an estimated 76.3 Mt CO_2-e, or 14.3% of Australia's total net emissions in 2000. The policies and measures described in this section reflect key actions to reduce greenhouse gas emissions from passenger and freight transportation as outlined in Module 5 of the NGS – *Efficient Transport and Sustainable Urban Planning*. This module encompasses a range of measures including improving vehicle fuel efficiency and technologies, reducing the demand for travel and facilitating smoother traffic flows, integrating land use and transport planning, and encouraging greater use of public transport, walking and cycling by influencing the behaviour of transport users.

ENVIRONMENT STRATEGY FOR MOTOR VEHICLE INDUSTRY

Greenhouse gases affected

CO_2 / CH_4 / N_2O

The Environmental Strategy for the Motor Vehicle Industry aims to significantly enhance the environmental performance of the automotive industry through measures including consumer information programs.

Fuel Consumption Labelling Scheme

A Fuel Consumption Labelling Scheme has been developed for new vehicles under 2.7 tonnes. From January 2001, all new cars sold in Australia are required by law to carry a fuel consumption label on the windscreen at the point of sale. The label applies to passenger vehicles, four wheel drives (4WDs) and light commercial vehicles up to 2.7 tonnes gross vehicle mass. The label shows how many litres of fuel the car uses to travel 100 km, in city conditions, tested according to *Australian Standard AS 2877*. The label scheme applies to all petrol, diesel and LPG passenger vehicles. However only petrol light commercial vehicles and 4WDs require the label. The fuel consumption label aims to raise consumer awareness of fuel efficient cars and their role in helping to reduce greenhouse gas emissions. It helps consumers to make informed choices about new car purchases that will help reduce greenhouse emissions while returning an economic benefit through lower fuel running costs.

Fuel Quality Standards Act 2000

The Commonwealth Parliament enacted the *Fuel Quality Standards Act 2000* in December 2000. The Act regulates the quality of fuel to reduce pollutants and emissions arising from the use of fuel that may cause environmental, greenhouse and health problems, facilitates the adoption of better engine and emission control technologies, and allows the more effective operation of engines.

ALTERNATIVE FUELS PROGRAMS

Greenhouse gases affected

CO_2 / CH_4 / N_2O

The aim of the Commonwealth's Alternative Fuels Programs is to increase the use of alternative fuels, especially compressed natural gas (CNG) and liquefied petroleum gas (LPG), in medium to heavy road vehicles in order to reduce greenhouse gas and other vehicular emissions from the transport sector. The strategy is designed to maximise the emissions reduction and running cost advantages of alternative fuels and includes a number of specific programs.

In January 2000, the Alternative Fuels Conversion Program ($75 million) commenced, with the objective of providing assistance to the operators of heavy commercial vehicles (weighing 3.5 tonnes gross vehicle mass or more) and buses to convert their vehicles to operate on either CNG or LPG, or to purchase new vehicles running on these fuels. Applications covering the conversion of over 550 vehicles have been approved.

A number of States and Territories are also encouraging conversion of buses from diesel to cleaner burning gas. The South Australian Government has made a commitment to cleaner fuels by purchasing nearly 200 CNG buses and establishing refuelling facilities. By November 2001, close to 30% of the metropolitan bus fleet will be fuelled by CNG. In Queensland, the Brisbane public transport bus fleet is being upgraded through the purchase of 120 CNG buses over the next three years. The WA Government announced, in October 2000, a cash incentive scheme to encourage the purchase of LPG powered vehicles and the conversion of existing vehicles to LPG. In NSW, there will be 404 CNG buses by the end of 2001, representing around a quarter of the State Transit public transport fleet.

The Compressed Natural Gas Infrastructure Program ($7.6 million) has already provided financial assistance for 19 additional publicly accessible CNG refuelling sites around Australia, including sites in Queensland, NSW, Victoria and South Australia. The objective of the program is to support the development of a commercially sustainable and publicly accessible network of CNG refuelling stations, as many local government authorities around Australia are keenly interested in establishing refuelling stations to support their natural gas vehicle fleets. The aim is to encourage fleet operators to switch to CNG. The number of publicly accessible CNG refuelling sites is expected to increase to over 30 within the next 18 months.

The Diesel and Alternative Fuels Grants Scheme commenced in July 2000 and will maintain price relativities between diesel and a range of alternative fuels by allowing eligible transport operators to obtain alternative fuel grants. The retention of the existing price differential between diesel and alternative fuels aims to encourage wider use of alternative fuels and reduce greenhouse gas emissions and improve air quality.

STRATEGIC TRANSPORT PLANNING

Greenhouse gases affected

CO_2 / CH_4 / N_2O

State and Territory Governments have adopted a number of measures to reduce transport-related greenhouse gas emissions. The ACT has introduced a new bus network, reviewed the effectiveness of a number of measures designed to encourage car pooling and begun work on a parking policy and a pedestrian strategy. In November 1998, the NSW Government released an integrated transport plan for Sydney and regional NSW, Action for Transport 2010 – a fully funded, comprehensive package of new transport initiatives.

The Queensland Government is implementing the South East Queensland Integrated Regional Transport Plan, which is targeting mode share increases of 50% for public transport, 15% for walking and 300% for cycling. Through its Living Neighbourhoods Program, the South Australian Government has successfully developed and implemented a travel behaviour change scheme to assist individuals change their travel patterns. The NT Government has finalised a public transport strategy which includes a number of measures aimed at encouraging greater use of public and low emission transport modes, and incorporating public transport issues into land use planning.

In Western Australia, the ten-year TravelSmart Program aims to change people's travel habits and motivate them to use alternatives such as walking, cycling, public transport, car pooling or 'teleaccess' (working from home). Trial results through the TravelSmart Workplace Program have demonstrated a 10% behaviour shift in participants from commuting by car to public transport, cycling, walking, car pooling or working from home. The Victorian Government has allocated approximately $1 billion under its Linking Victoria Program to improve Victoria's public transport system.

The Northern Territory, South Australian and Commonwealth Governments, along with a private consortium, have also invested significantly in the extension of the railway line from Alice Springs to Darwin in the Northern Territory. Construction has commenced and should be completed in 2003. The development of the railway will see a significant modal shift for freight between Darwin and southern Australian States from long haul road transport to rail, resulting in reductions in greenhouse gas emissions.

The National Transport Secretariat is developing a strategy for reducing transport-related greenhouse gas emissions which aims to deliver both long-term and short-term reforms at both the Commonwealth and State and Territory levels. This strategy will be presented to the Australian Transport Council comprising Commonwealth, State and Territory Transport Ministers.

NATIONAL BICYCLE STRATEGY

Greenhouse gases affected

CO_2 / CH_4 / N_2O

Australia Cycling – The National Strategy 1999 – 2004 is focused on developing best practice guidelines for local councils on cycling policy, planning and infrastructure. The Commonwealth, States and Territories are also exploring options to remove legal, regulatory and planning barriers to walking and cycling, and to facilitate the integration of cycling into the transport network.

Land Use Change and Forestry

In 2000 forestry comprised a net sink of around 23.7 Mt CO_2-e. It is estimated that land use change (forest conversion) in 2000 contributed about 64.8 Mt CO_2-e to Australia's total net emissions and that emissions from the Land Use Change and Forestry sector in total comprised 38 Mt CO_2-e.

Land-use change and forestry, through increasing and protecting vegetation cover, is an important means of enhancing Australia's greenhouse gas sink capacity. Increasing the area of production forests, particularly through reforestation and farm forestry, and increasing vegetation cover provide important opportunities for carbon sequestration, in addition to other environmental benefits such as salinity mitigation and biodiversity conservation. The policies and measures detailed in this section reflect key initiatives to enhance greenhouse sinks and encourage sustainable forestry and vegetation management as set out in Module 6 of the NGS – *Greenhouse Sinks and Sustainable Land Management*.

NATURAL HERITAGE TRUST – LAND AND VEGETATION PROGRAMS

Greenhouse gases affected

CO_2 / CH_4 / N_2O

The Commonwealth has continued with the implementation of various policies and measures under its Natural Heritage Trust (NHT) which is aimed at achieving sustainable agriculture and land use practices and enhancing natural resource management. A reduction in greenhouse gas emissions in the Land Use Change and Forestry sector is one of the objectives of these sustainability policies. The NHT does this by providing funding for environmental activities at the community and regional levels, as well as at the State and Territory and national levels. In its 2001 Budget, the Commonwealth Government allocated a further $1 billion over five years from 2002/2003 to extend the operation of the NHT.

Bushcare is a key program of the NHT aimed at protecting, enhancing and increasing native vegetation in the landscape. The national goal of Bushcare is to reverse the long-term decline in the quality and extent of Australia's native vegetation cover. Working with community groups, land managers, industries and government agencies at all levels, Bushcare aims to conserve, enhance and sustainably manage remnant native vegetation and greatly increase and improve revegetation activities, as well as encourage the integration of native vegetation into conventional farming systems.

The Commonwealth's National Landcare Program supports community-based action in achieving sustainable agricultural production systems. Local landholders undertake projects which contribute to the sustainable management of land and vegetation, thereby enhancing Australia's greenhouse sink capacity and contributing to the reduction of greenhouse gas emissions from land-based sources. There are now more than 4 500 landcare groups across Australia – about one in every three farmers is a member of a landcare group.

The Farm Forestry Program, which is also funded under the NHT, aims to encourage the incorporation of commercial tree growing and management on cleared agricultural land into farming systems for the purpose of wood and non-wood production, providing substantial environmental benefits such as lowering water tables and reducing salinity. Strong networks to support farm forestry have been established across plantation growing areas of Australia. Several State Governments also have farm forestry programs providing funding and support for incorporating tree growing into farming systems.

PLANTATIONS FOR AUSTRALIA – THE 2020 VISION

Greenhouse gases affected

CO_2

Plantations for Australia – The 2020 Vision outlines the shared vision for Australia's plantations between the Commonwealth and State Governments and industry. The objectives of the program are to remove impediments to Australian plantation establishment. The target is to treble the effective area of Australia's plantations between 1996 and 2020 by planting an average of 80 000 hectares per year. The rate of plantation expansion has quadrupled between 1995 and 2000, from 30 300 hectares to 125 000 hectares per year. Up to $3 billion (of mainly private capital) could be invested to establish new plantations by 2020.

States and Territories have also implemented plantation strategies. For example, Western Australia has pioneered the development of commercial tree crops for cleared agricultural land with an estimated 100 000 hectares of hardwood and 8 000 hectares of softwood plantations established on previously cleared land between 1995 and 1999. The NSW Government has also invested significantly in new plantations. By 2004, the State-owned or managed hardwood plantation estate will have increased by almost 35 000 hectares since 1995. State Forests of NSW is also actively promoting private investment in planted forests.

In South Australia, plantation forests are expected to increase to approximately 330 000 hectares by 2020, with 13 000 hectares of new plantation forests being established between 1997 and 1999. Victoria has also seen a rapid expansion of its plantation estate since 1997, with over 60 000 hectares (predominantly blue gums) planted by the private sector. Plantation establishments in Queensland through the South East Queensland Government Stakeholder Forest Agreement 1999 are estimated to result in 10 million trees being planted over five years from 2001.

BUSH FOR GREENHOUSE

Greenhouse gases affected

CO_2

Bush for Greenhouse is an initiative of the Prime Minister's Safeguarding the Future package with funding of $5.5 million over five years. Bush for Greenhouse aims to increase Australia's sinks capacity by increasing corporate investment in revegetation for environmental purposes. Bush for Greenhouse has developed technical, legal and administrative tools that provide information and carbon accounting capacity to facilitate investment in greenhouse sinks in the private and public sectors.

NATIONAL ACTION PLAN FOR SALINITY AND WATER QUALITY

Greenhouse gases affected

CO_2 / CH_4 / N_2O

The National Action Plan for Salinity and Water Quality was endorsed by the Commonwealth, States and Territories at the Council of Australian Governments in November 2000. A key objective of the National

Action Plan is to prevent, stabilise and reverse trends in dryland salinity. As one of the important tools for addressing dryland salinity is revegetation and vegetation protection, it is expected the National Action Plan will substantially enhance Australia's greenhouse sink capacity.

The National Action Plan is focused on investment in catchment/region management plans for improved salinity and water quality in 21 priority regions. It provides scope for investment in specific actions that enhance the contribution of vegetation to greenhouse sinks. This could be through a range of activities, including maintaining and improving the condition of existing native vegetation, and establishing multiple purpose perennial vegetation (focused on agriculture, forests, biodiversity and carbon credits) in targeted areas. It also provides for sustainable land management practices that may contribute to reducing greenhouse gas emissions from land-based sources.

OTHER LAND AND VEGETATION PROGRAMS

Greenhouse gases affected

CO_2

States and Territories have also implemented land and vegetation programs, which, through revegetation and vegetation protection, are expected to substantially enhance Australia's greenhouse sink capacity. Under NSW's Native Vegetation Management Fund, some 77 000 hectares of land have now been put under management agreements with private landholders to ensure the retention of native vegetation. Victoria's Growing Victoria's Greenhouse Sinks Program has focused on long-term environmental plantings, promoting biodiversity and reducing land and water degradation.

Agriculture

Agriculture produced an estimated 98.4 Mt CO_2-e emissions or 18.4% of Australia's total net emissions in 2000. These emissions consisted principally of methane (CH_4) from the digestive systems of cattle and sheep and nitrous dioxide (N_2O) from soils. Module 6 of the NGS – *Greenhouse Sinks and Sustainable Land Management* – outlines the framework of action to reduce greenhouse gas emissions from agricultural production through sustainable farming practices to support productivity and the long-term viability of agricultural enterprises.

REDUCING METHANE EMISSIONS FROM LIVESTOCK

Greenhouse gases affected

CH_4

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is continuing with its development of a vaccine to reduce livestock methane emissions. In trials the vaccine has shown the potential to reduce methane emissions, as well as enhance live weight gain and wool growth. Funding of $1 million has been provided as part of the Prime Minister's Safeguarding the Future package to promote this vaccine and work is currently under way to seek to make it commercially available.

GREENHOUSE CHALLENGE AGRICULTURAL STRATEGY

Greenhouse gases affected

CH_4 / N_2O

The Greenhouse Challenge program has been expanded to include significant numbers of enterprises in the agriculture sector through the Greenhouse Challenge Agricultural Strategy. In cooperation with some 10 industry associations, the Australian Greenhouse Office is engaged in promoting agricultural management

practices that deliver reductions in greenhouse gas emissions. Specific projects include an analysis of sustainable land management practices and greenhouse outcomes, identifying ways to reduce machinery, fertiliser and irrigation water over-use, improving livestock nutrition, and the collation and dissemination of material on greenhouse and agricultural issues. Additional activities will be explored to improve abatement methods for non-CO_2 gases that make up the bulk of agriculture emissions.

GREENHOUSE AND AGRICULTURE TASKFORCE

Greenhouse gases affected

CH_4 / N_2O

In 2000 the Commonwealth established the Greenhouse and Agriculture Taskforce, which aims to encourage the exchange of information between agricultural sector representatives, policy makers and researchers to facilitate the uptake of actions to reduce greenhouse gas emissions in the agriculture sector and enhance its competitiveness. The Taskforce supports the development of commodity-specific information on climate change and practical actions that can be implemented to improve productivity and decrease overall greenhouse gas emissions. An issues paper has been prepared to provide a basis for a strategic framework for greenhouse and agriculture. It identifies greenhouse objectives for the agriculture sector that will guide the identification of priority actions and implementation responsibilities.

AGRICULTURE WORK SECTOR PROGRAM

Greenhouse gases affected

CH_4 / N_2O

The Department of Agriculture, Fisheries and Forestry and the Australian Greenhouse Office are overseeing a work program designed to incorporate consideration of greenhouse issues into agricultural management practices. The first phase of the work program involved a series of nine workshops where representatives of government, science and industry have met to prioritise actions for agriculture to reduce net emissions and meet the challenge of climate change. It is proposed to develop these priority actions in a second phase.

Industrial Processes and Fugitive Emissions

Actions to address greenhouse gas emissions from industry are outlined in Module 7 of the NGS – *Greenhouse Best Practice in Industrial Processes and Waste Management*. Emissions from industry and commercial activities are predominantly generated through energy use in manufacturing and industrial processes (primarily in the form of electricity), but also from transportation and fugitive emissions. Activities to abate these emissions are discussed in the section on energy in this chapter and, given their cross-sectoral nature, are also included in the cross-sectoral section of this chapter. Programs like Greenhouse Challenge and GGAP are examples of government partnering with industry to reduce their greenhouse gas emissions. This section focuses on measures to abate emissions from specific industrial processes, which are a by-product of the various production and manufacturing processes as a result of the chemical transformation of materials.

INDUSTRIAL PROCESSES

Greenhouse gases affected

HFCs / PFCs / SF_6

Direct emissions from these industrial processes (for example, aluminium and cement production) account for only a small percentage of Australia's total net emissions and cover the full range of greenhouse gases. Total emissions from industrial processes were 10.3 Mt CO_2-e in 1999, or 1.9% of Australia's total net emissions.

This total does not fully reflect the greenhouse impact of industry, however, given that emissions from energy consumption by industry are included in the energy sector.

Synthetic greenhouse gases in industrial processes

Synthetic greenhouse gases are used and emitted by a wide range of Australian industries, including aluminium and magnesium production, electricity supply, refrigeration and air conditioning, foam blowing, fire prevention, aerosols and solvents. Emissions of synthetic greenhouse gases do not currently contribute significantly to Australia's total net emissions. Given their comparatively high global warming potentials (GWP) and the expected increase in their use, driven largely by industries covered by the Montreal Protocol on Substances that Deplete the Ozone Layer that are replacing ozone depleting substances with synthetic greenhouse gases, there is significant potential for emissions of synthetic gases to grow.

The Commonwealth has taken steps to manage synthetic greenhouse gas emissions. Initial work has focused on identifying current and likely future uses and emission sources of synthetic greenhouse gases and engaging stakeholders in discussion on the range of technical response options for limiting emissions. This has included commissioning detailed research on trends in synthetic gas use and emissions to improve the National Greenhouse Gas Inventory, data collection regimes and methodologies and projections data. Additionally, discussions and workshops have been held with the electricity supply industry within the Greenhouse Challenge framework to develop reporting and handling guidelines to manage SF_6 emissions.

Specific measures have included the banning of the importation of non-refillable containers of hydrofluorocarbons (HFCs) intended for use as refrigerants under the *Customs Prohibited Imports Regulations* as of July 2000 and providing funding of $3.6 million to industry under GGAP for a suite of training, certification and recovery programs aimed at minimising emissions of HFCs in the refrigeration and air-conditioning industry. This funding will cover the establishment of an on-going training and certification program to assist air-conditioning and refrigeration technicians to adopt environmentally sensitive practices for dealing with HFCs and support Refrigerant Reclaim Australia, an industry-funded body, to recover, reclaim and destroy used HFCs.

Aluminium industry and Greenhouse Challenge – partnering to reduce PFC emissions

The aluminium industry, one of Australia's leading industries and fourth largest global exporter of aluminium, began its perfluorocarbon (PFC) reduction program in the early 1990s. It has achieved impressive reductions in PFC emissions including through its partnership with the Australian Government under the Greenhouse Challenge program. As a result of these activities, emissions of PFCs from aluminium smelting between 1990 and 1997 fell by more than 70%, despite an increase in aluminium production of about 13%. Australia is among world leaders in producing aluminium with low emissions of PFCs.

FUGITIVE EMISSIONS

Greenhouse gases affected

CO_2 / CH_4 / N_2O

Fugitive emissions result from the production, processing, transport, storage, transmission and distribution of raw fossil fuels, but do not include emissions from fuel combusted for process energy. Total estimated fugitive emissions for 2000 were 31.5 Mt CO_2-e, or 5.9% of Australia's total net emissions.

Action to reduce fugitive emissions has been addressed by measures such as Greenhouse Challenge and GGAP. Through Greenhouse Challenge, which has wide coverage of emissions from oil, gas and coal mining, companies have entered into cooperative agreements to reduce fugitive emissions. Oil and gas companies are working to develop flaring policies and implement flaring-reduction strategies, while oil and gas industry bodies, through facilitative agreements, have committed to work with their members to examine measures such as the collection and utilisation of flared and vented gas.

The Queensland Government's Cleaner Energy Strategy commits $1.5 million over five years to assist the coal industry to install equipment to capture and use waste mine gas from coal mines. The Queensland Government will set a target to reduce waste gas emissions from coal mines by 2.5 Mt CO_2-e over 4 years. The Queensland Government expects to reduce waste gas emissions from coal mines by around 10 Mt CO_2-e by 2012.

Waste management

Methane (CH_4) is the dominant emission from municipal solid waste disposal on land and waste water disposal. The total sector emissions for 2000 were estimated at 16.7 Mt CO_2-e, or 3.1% of Australia's total net emissions. Measures to achieve reductions in greenhouse gas emissions from waste management are set out in Module 7 of the NGS – *Greenhouse Best Practice in Industrial Processes and Waste Management*.

NATURAL HERITAGE TRUST – WASTE MANAGEMENT AWARENESS PROGRAM

Greenhouse gases affected

CH_4

The Commonwealth allocated $6 million from the NHT over six years to June 2002 to the Waste Management Awareness Program. It promotes the benefits and practicalities of effective waste management and recycling, with an emphasis on community based activities. Projects target waste management and recycling issues where there is a need for national action and where support can most make a difference. Program outcomes are to contribute to the diversion of waste from landfill, improved community and industry awareness and behaviour on waste management issues, and increased market opportunities for recycled and recovered materials.

WASTE MANAGEMENT STRATEGIES

Greenhouse gases affected

CH_4

Policies and measures adopted and implemented by States and Territories and local government are focused towards reducing and capturing methane emissions from the waste sector. Most State and Territory Governments, as well as the majority of local councils, have waste minimisation and re-use strategies in place which implement the Waste Minimisation and Recycling Strategy. The Green and Organic Waste Management Strategy (1996) is being implemented by States, Territories and local government.

The ACT Government is implementing the No Waste to Landfill by 2010 Strategy. One priority is a Methane Capture and Electricity Generation Program. Two power stations became operational in early 2000 using CH_4 extracted from landfill and marketed as green energy. The energy produced by CH_4 capture will eventually be enough to power half the schools and one third of the streetlights for the ACT for ten years, or 3 000 homes for 30 years.

The Victorian Government's Green Waste Action Plan has a goal of reducing organic material going to landfills by 50% by 2010. Victoria's Environment Protection Authority has published *Best Practice Environmental Management Guideline – Reducing Greenhouse Gas Emissions from Landfills and Wastewater Treatment Facilities*. The Guideline provides the waste management industry with a strategic framework for selecting the best practice option for waste management.

In NSW, SEDA has encouraged the avoidance of greenhouse gas emissions from landfills through the funding of waste-to-energy projects. SEDA's Renewables Investment Program has supported various waste management strategy developments, including the capture of landfill gas emissions for use in energy generation at two regional landfills, a biogas plant which will transform 80 000 tonnes of food waste per annum – formerly disposed to landfill – into green energy and fertiliser, and a solid waste energy recycling facility which will turn up to 100 000 tonnes of waste per annum into renewable electricity.

Table 4.1 Summary of policies and measures by sector[1]

STATIONARY ENERGY							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
3.1	Government operations	Reducing greenhouse gases from government operations	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Commonwealth (Cth) States & Territories (S&T)	0.5*
3.4, 3.7	Local government – miscellaneous additional energy efficiency measures	Cities for Climate Protection™ and Household Greenhouse Action	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements/ Education	Implemented	Cth S&T	Included in estimate of State and Territory action under the NGS below
3.5	Greenhouse Challenge (Energy efficiency)	Extension and expansion of the Greenhouse Challenge Program, energy efficiency actions only	$CO_2/CH_4/N_2O$	Voluntary	Implemented	Cth	6.7 to 10.3*
4.1	Energy market reform (including extension)	Accelerating and monitoring energy market reform	$CO_2/CH_4/N_2O$	Regulatory	Implemented	Cth S&T	-0.7 to 0.5*
4.2	Generator Efficiency Standards	Strategies for energy industries to abate greenhouse gas emissions	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Cth	3.6 to 5.4*
4.3	Strategies for energy retailers	Includes conditions on licences or cooperative arrangements between companies and governments	$CO_2/CH_4/N_2O$	Regulatory	Implemented	S&T	Included in estimate of State and Territory action under the NGS below
4.6	Strategic development of renewable energy	Renewable Energy Commercialisation Program; Renewable Energy Showcase Program; Renewable Remote Power Generation Program; Renewable Energy Equity Fund; Photovoltaic Rebate Program	$CO_2/CH_4/N_2O$	Economic	Implemented	Cth	Included in MRET estimate below
4.7	Mandatory Renewable Energy Target (MRET)	Mandatory targets for the uptake of renewable energy in power supplies	$CO_2/CH_4/N_2O$	Regulatory	Implemented	Cth	6.7 to 7.8*

Table 4.1 (continued) Summary of policies and measures by sector[1]

STATIONARY ENERGY (CONTINUED)							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
4.8	National Green Power Accreditation Program	Facilitate installation of new renewable energy generators and encourage consumer demand for electricity generated from renewable sources	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	S&T	Included in estimate of State and Territory action under the NGS below
4.9	Energy efficiency standards for residential and commercial buildings	Introduction of minimum energy performance requirements for residential and commercial buildings	$CO_2/CH_4/N_2O$	Regulatory	Planned	Cth S&T	2.1*
4.10	Energy performance codes for domestic appliances and industrial equipment	Introduction of energy performance codes and standards for domestic appliances and commercial and industrial equipment	$CO_2/CH_4/N_2O$	Regulatory	Implemented	Cth S&T	7.2*
4.16	Energy Efficiency Best Practice and Benchmarking Program	Assist industry in the efficient use of energy through innovation, training and benchmarking	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Cth	1.5*
Modules 3 and 4	Additional State and Territory action under the NGS	Variety of programs including NGS 3.1, 3.4, 3.7, 4.3, 4.5, 4.8, 4.10 4.12, 4.14, 4.15 and 4.18	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements/ Regulatory	Implemented	S&T	2.5*
–	Double inclusion	Emissions savings that may be double counted across energy efficiency measures	$CO_2/CH_4/N_2O$	–	–	–	-5.6*
–	Eco-efficiency Program	Agreements with peak industry bodies to demonstrate and monitor eco-efficiency practices	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Cth	Not estimated
Total Stationary Energy[2]							24.5 to 32.2

Table 4.1 (continued) Summary of policies and measures by sector[1]

TRANSPORT							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
5.2, 5.3, 5.6	Improved national strategic transport planning	Strategy development for reducing transport emissions	$CO_2/CH_4/N_2O$	Various	Planned	Cth S&T	Not estimated
5.9	National bicycle strategy	Guidelines for cycling planning policy and infrastructure	$CO_2/CH_4/N_2O$	Information	Implemented	Cth S&T	Not estimated
5.10	Environmental strategy for the motor vehicle industry	National average fuel consumption targets for new vehicles	CO2/CH_4/N_2O	Information/ Regulatory	Implemented	Cth	2.0*
5.12	Diesel and alternative fuel grants scheme	Reduced the incentive to switch from using alternative fuels to diesel	$CO_2/CH_4/N_2O$	Economic	Implemented	Cth	Included in BAU*
5.12	Alternative fuels conversion program	Subsidy for conversion of vehicles to use alternative fuel	$CO_2/CH_4/N_2O$	Economic	Implemented	Cth	Included with CNG infrastructure*
5.12	CNG infrastructure program	Subsidy of CNG refuelling stations	$CO_2/CH_4/N_2O$	Economic	Implemented	Cth	0.5*
Module 5	Additional State and Territory actions under the NGS	NGS measures 5.2, 5.7 and 5.9	$CO_2/CH_4/N_2O$	Various	Implemented	S&T	1.4*
Total Transport[3]							**3.9**

Table 4.1 (continued) Summary of policies and measures by sector[1]

LAND USE CHANGE FORESTRY							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
6.1	Plantations for Australia – The 2020 Vision	Remove impediments to plantation establishment	CO_2	Economic/ Information	Planned	Cth S&T Industry	Not estimated
6.1	The Farm Forestry Program	Expediting farm forestry	CO_2	Economic/ Information	Implemented	Cth	Not estimated
6.2	Natural Heritage Trust – land and vegetation programs	Environmental plantings	CO_2	Economic/ Information	Implemented	Cth S&T	Partial indicative estimate only
6.3	Bush for Greenhouse	Increase sink capacity through facilitating corporate investment in revegetation	CO_2	Economic/ Information	Adopted	Cth	Not estimated
–	National Action Plan for Salinity and Water Quality	Enhance sink capacity by preventing, stabilising and reversing trends in dryland salinity	CO_2	Economic/ Information	Implemented	Cth	Not estimated
Total Land-Use Change and Forestry[4]							**Not estimated**

Table 4.1 (continued) Summary of policies and measures by sector[1]

AGRICULTURE							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
6.9	Residue burning	Reduction of stubble burning practices	CH_4/N_2O	Voluntary/ Negotiated agreements	Adopted	Cth S&T	0.1*
6.9	Nitrification inhibitor	Increase the percentage of fertiliser with additive to reduce nitrification	N_2O	Voluntary/ Negotiated agreements	Adopted	Cth S&T	0.02*
6.9	Reduced fertiliser application	Reduce percentage of fertiliser applied by 15%	N_2O	Voluntary/ Negotiated agreements	Adopted	Cth S&T	0.9*
6.9	Waste management	Modify farm management practices to reduce methane	CH_4	Voluntary/ Negotiated agreements	Adopted	Cth S&T	0.05*
6.9, 6.10	Greenhouse and Agriculture Taskforce	Facilitate uptake of actions through exchange of information	CH_4/N_2O	Information	Implemented	Cth S&T	Not estimated
6.9	Agriculture Sector Work Program	Work program to incorporate greenhouse issues into agricultural management practices	CH_4/N_2O	Information	Implemented	Cth S&T	Not estimated
6.11	Rumen modifiers	Modification of rumen methanogens to decrease methane emissions	CH_4	Research	Adopted	Cth S&T	0
Total Agriculture							**1.1**

INDUSTRIAL PROCESSES							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
7.1	Greenhouse Challenge (Process emissions for aluminium and clinker)	Agreement to reduce industrial process emissions (as distinct from energy combustion emissions)	CO_2/PFCs	Voluntary	Implemented	Cth	4.9*
Total Industrial Processes							**4.9**

Table 4.1 (continued) Summary of policies and measures by sector[1]

FUGITIVE							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
7.1	Greenhouse Challenge (Coal emissions)	Capture of waste coal mine gas	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Cth	2.3*
7.1	Greenhouse Challenge (Oil and Gas emissions)	Reduction in venting and flaring	$CO_2/CH_4/N_2O$	Voluntary/ Negotiated agreements	Implemented	Cth	0.3*
Total Fugitive[5]							**2.6**

WASTE							
NGS Measure	**Name of policy or measure**	**Objective and/or activity affected**	**Greenhouse gas affected**	**Type of instrument**	**Status**	**Implementing entity or entities**	**Saving in 2010 Mt CO_2-e**
7.3, 7.4, 7.5	Solid waste and waste water management strategies	Reduction in disposal of organic waste to landfil and reduction of methane emissions from landfills and waste water facilities	CH_4	Voluntary/ Regulatory/ Economic	Implemented	S&T and local government	7.7*
–	Natural Heritage Trust-Waste Management Awareness Program	Promote benefits of waste reduction and recycling	CH_4	Information	Implemented	Cth	Not estimated
Total Waste							**7.7**

Table 4.1 (continued) Summary of policies and measures by sector[1]

CROSS-SECTORAL POLICIES AND MEASURES							
NGS Measure	Name of policy or measure	Objective and/or activity affected	Greenhouse gas affected	Type of instrument	Status	Implementing entity or entities	Saving in 2010 Mt CO_2-e
–	Greenhouse Gas Abatement Program (GGAP)	Market based allocation of grants to cost effective abatement opportunities	$CO_2/CH_4/N_2O/$ PFCs/HFCs/SF_6	Economic	Implemented	Cth	10.8*
–	Greenhouse Friendly Program	Certification and labelling program where emissions have been offset by abatement projects	$CO_2/CH_4/N_2O/$ PFCs/HFCs/SF_6	Information/ Economic	Adopted	Cth	Not estimated
–	Emissions trading	National emissions trading scheme	$CO_2/CH_4/N_2O/$ PFCs/HFCs/SF_6	Economic/ Information	Planned	Cth	Not estimated
–	International Greenhouse Partnerships (IGP)	Project-based flexibility mechanisms	$CO_2/CH_4/N_2O/$ PFCs/HFCs/SF_6	Information/ Education	Implemented	Cth	Not estimated

1 This table summarises policies and measures set out in this chapter, including an estimate of abatement in 2010. Abatement has not been estimated for programs that are either broadly related to information dissemination rather than specific actions, or for which information is not yet available to provide an estimate. The term 'not estimated' is used in both cases.

2 The 1997 estimate for stationary energy included another 1.0 Mt CO_2-e of other measures from the Prime Minister's Safeguarding the Future package. These are now incorporated in other estimates in the table.

3 The 1997 estimate for transport included another 0.5 Mt CO_2-e for other measures under the National Greenhouse Response Strategy. These are now incorporated in the estimate for the Environmental Strategy for the Motor Vehicle Industry.

4 Not all measures have been estimated.

5 Fugitive measures in 1997 were reported at 14.2 Mt CO_2-e. This figure contains a double counting of 6.6 Mt CO_2-e of emissions savings.

* Measure is included in the 'with measures' projection.

CHAPTER FIVE
PROJECTIONS

This chapter presents projections for Australia's greenhouse gas emissions. 'With measures' projections are reported for each National Greenhouse Gas Inventory sector, with a focus on 2010.

According to the international guidelines for National Communications, projections of emissions presented in this chapter principally are made in accordance with the provisions of the United Nations Framework Convention on Climate Change (UNFCCC).

It is important to note that the rules for preparing Inventories and emission projections under the Kyoto Protocol have some key differences relative to the UNFCCC. For example, by using the UNFCCC comprehensive definition of Forestry, the 1990 baseline is significantly reduced below the level appropriate for analysing progress towards Australia's Kyoto target. The differences in the accounting rules mean that the emissions projections for the UNFCCC and for the Kyoto targets are different.

To complete the picture, projections according to the implementation rules for Kyoto emissions targets are also provided. Australia's Kyoto target is 108% of 1990 emissions levels.

Business as usual (BAU) refers to a projection of emissions under the assumption that no specific action is taken to reduce greenhouse gases beyond what would have occurred in the normal course of development in Australia. Specific actions that have been taken to reduce greenhouse gas emissions are termed 'measures' and the 'with measures' projection reflects the likely net level of emissions.

These projections were compiled in 2001 and have been supplemented with Land Use Change emissions estimates from the National Carbon Accounting System produced in mid–2002. The Australian Greenhouse Office has an ongoing program to regularly update and improve sectoral emissions projections, taking account of new data and changing economic circumstances. Future work includes the incorporation of additional sensitivity and

scenario analysis designed to improve the confidence in the national projections of both BAU and 'with measures' greenhouse gas emissions.

This chapter starts with a sector by sector explanation of projections, including the approach adopted, key assumptions and results. The sectors are defined to be consistent with the National Greenhouse Gas Inventory. The second section of this chapter provides a summary of results showing the aggregate effects of policies and measures implemented at Commonwealth, State and Territory and local government levels. The final section provides a description of the methodology applied and associated uncertainties.

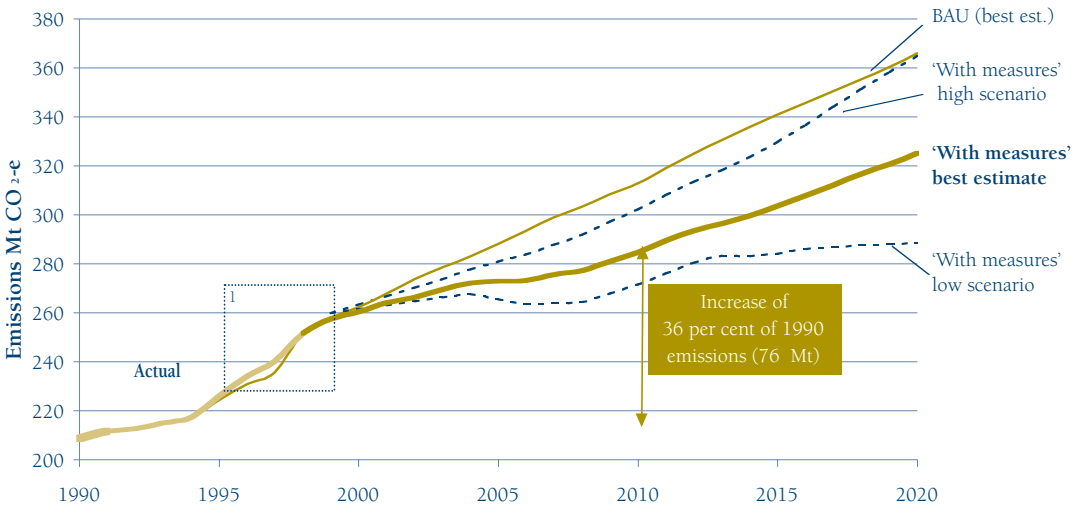
PROJECTIONS – SECTOR BY SECTOR

The following section discusses the best estimate projections for BAU, the impact of measures and 'with measures' projections for each sector. In most cases a range is provided to indicate the level of uncertainty and this is shown in the corresponding figure for each sector. It should be noted that, for simplicity, only the best estimate for BAU is presented in the figures. In all cases (high, best estimate and low) there is a reduction in emissions as a result of policies and measures. The high 'with measures' estimate reflects the high BAU projection with a low impact of measures, while the low 'with measures' projection reflects the low BAU projection, with a high impact of measures.

Projections of Stationary Energy sector emissions

Stationary Energy includes emissions from the generation of electricity and the direct consumption 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.

Figure 5.1 Emissions from the Stationary Energy sector, 1990 to 2020



1. The rapid increase in emissions over the period 1997 to 1999 reflects, amongst other things, an increased use of brown coal for electricity generation and a significant jump in electricity consumption. The National Greenhouse Gas Inventory (shown as the 'Actual' line) includes the impact of all measures and lies above the BAU best estimate in the period 1995 to 1999 due to the impact of energy market reform over that period.

Factors influencing sectoral emission projections

Growth in emissions from this sector is attributable to a range of factors including:

- gross domestic product (GDP) and population growth;
- sectoral activity and structural change;

- major projects (including 'greenfield' and expansion of existing facilities); and
- fuel mix.

Emissions growth is tempered by ongoing improvements in energy efficiency and the greater use of less carbon intensive fuels such as natural gas and renewables.

Analytic approach followed

The projection for this sector uses a combination of top down and bottom up economic models. The top down models (Global Trade and Environment Model (GTEM), Monash Multi-Regional Forecasting-Green (MMRF-Green) and Global General Equilibrium Growth Model (G-Cubed)) are computable general equilibrium models. The Australian Bureau of Agriculture and Resource Economics (ABARE) uses the GTEM model, the Centre of Policy Studies (CoPS) uses the MMRF-Green model and the Centre for International Economics (CIE) uses the G-Cubed model. The GTEM projection is included in all energy sector projections (stationary energy, transport and fugitive).

The bottom up models, which provide detailed specification of individual power generation and end users, are provided by McLennan Magasanik Associates (MMA) and National Institute of Economic and Industry Research (NIEIR). Differences in model results are derived from valid differences in fundamental assumptions (GDP, population, technological change and fuel share of electricity generation).

Assumptions

Table 5.1 Summary of key assumptions to 2010

Variable	Units	Modellers' Range
GDP	Annual % growth	2.4 to 3.7
Population	Annual % growth	0.7 to 1.2
Technological change	Annual % improvement	0.5 to 1.1
Electricity demand (BAU)	Annual % growth	2.7[1]
Gas share in electricity	% of generated electricity	13[1]

1. Approximate effective rates for the composite projection, derived from results for individual models.

Business as usual projections

Emissions from the stationary energy sector in 2010 are projected to be 313 million tonnes carbon dioxide equivalent (Mt CO_2-e) under BAU (range of 304 to 327 Mt CO_2-e). This represents 150% (range of 146 to 157%) of 1990 levels (209 Mt). While allowance has been made for known projects, the addition of significant energy intensive major projects has the potential to increase this projection. In addition, the projection assumes that by 2010 approximately 13% of electricity generated will be produced using gas. The projected level of emissions will increase to the extent that this is not achieved.

Effects of policies already in place ('with measures')

The impact of measures is estimated to be 28 Mt CO_2-e for a best estimate 'with measures' projection of 284 Mt CO_2-e in 2010. This represents an increase of 36% over 1990 levels. The emission projection range for this sector is shown in Figure 5.1. A list of current measures is provided in Table 5.2.

Greenhouse Challenge reporting arrangements have the potential to be used for multiple programs. It is therefore important to acknowledge and estimate any possible double inclusion of emissions savings in the estimates of performance of measures. At this stage, it is assumed that between one and two thirds of the

abatement from other energy efficiency programs such as the Energy Efficiency Best Practice and Benchmarking Program, Mandatory Energy Performance Standards, and Energy Efficiency Standards for Residential and Commercial Buildings could be reported under Greenhouse Challenge. It is assumed that there is no overlap between the National Greenhouse Strategy (NGS) Modules 3.1, 3.4 and 3.7 (see Table 5.2) as the target groups are distinct. The mid-point estimate of double inclusion (5.6 Mt) is incorporated in the total impact of measures for this sector.

Table 5.2 Impact of current measures in the Stationary Energy sector in 2010.

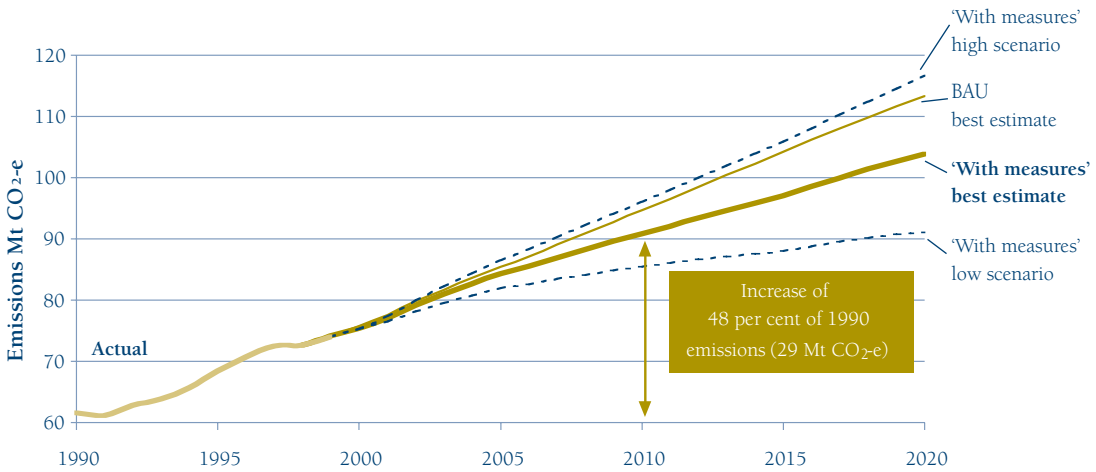
NGS Module	Measure	Mt Saving in 2010
3.1	Government operations (Commonwealth and local government only)	0.5
3.5	Greenhouse Challenge Program + extension	6.7 to 10.3
4.1	Energy Market Reform + extension	-0.7 to 0.5
4.2	Generator Efficiency Standards (GES)	3.6 to 5.4
4.7	Mandatory Renewable Energy Targets (MRET)	6.7 to 7.8
4.9	Energy Efficiency Standards in Residential and Commercial Buildings	2.1
4.10	Minimum Energy Performance Codes (MEPS)	7.2
4.16	Energy Efficiency Best Practice and Benchmarking Program (EEBP)	1.5
Various	Additional State and Territory actions under the NGS[1]	2.5
	Double Inclusion	-5.6
Total Stationary Energy sector		**24.5 to 32.2**

1. State and Territory actions also contribute to the other estimates of abatement measures listed in this table. This estimate includes additional action under NGS Modules 3.1, 3.4, 3.7, 4.3, 4.5, 4.8, 4.10, 4.12, 4.14, 4.15, 4.18.

Projections of Transport sector emissions

Greenhouse gas emissions from the transport sector include emissions from the direct combustion (or end use emissions) of fuels by road, rail, domestic air transport and domestic shipping and do not include the full fuel cycle emissions. Road transport is by far the most significant source of transport emissions. In this component of transport emissions, passenger motor vehicles, trucks and light commercial vehicles are the primary drivers and have been responsible for the majority of the growth in transport emissions.

Figure 5.2 Emissions from the Transport sector, 1990 to 2020



Factors influencing sectoral emission projections

Projected GDP growth (particularly for freight emissions) and population growth (for passenger car emissions) drive the steady growth in emissions from this sector. Beyond BAU improvements in fuel efficiency and introduction of less carbon intensive alternative fuels lowers the rate of growth ('with measures').

Analytic approach followed

The projection is derived by averaging results from two top down models GTEM (ABARE) and MMRF-Green (CoPS and Bureau of Transport Economics (BTE)) and a combined suite of bottom up models (one for each mode of transport) developed by the BTE.

Modellers' expectations of the relationship between income and population growth, and demand for transport services drive the most significant differences between the three projections.

Model development is underway on the MMRF-Green model to enhance the representation of transport and resolve differences between the top down and the bottom up approaches. Insights from this process will be included in future projections.

Assumptions

The main assumptions for transport are GDP and population growth (see Table 5.1). Each of the model classes has a significantly different structural relationship between road transport demand and these assumptions. In particular, BTE projections of private road transport have the elasticity of transport demand to population, and therefore the overall rate of growth in transport demand, declining in each year of the projection period as Australia reaches saturation point in terms of vehicle ownership per person. The top down models do not have this type of constraint built in, because as incomes rise householders will continuously demand more private road transport services.

Business as usual projections

Emissions from the transport sector in 2010 are projected to be 94.7 Mt CO_2-e under BAU (range of 89.9 Mt CO_2-e to 99.4 Mt CO_2-e). This represents 154% (range of 146 to 162%) of 1990 levels (61.5 Mt CO_2-e).

Effects of policies already in place ('with measures')

The impact of measures is estimated to be 3.9 Mt CO_2-e for a 'with measures' projection of 90.8 Mt CO_2-e in 2010, which represents an increase of 48% over 1990 levels. The emission projection range for this sector is shown in Figure 5.2. A list of measures and impacts is provided in Table 5.3.

Table 5.3 Impact of current measures in the Transport sector in 2010

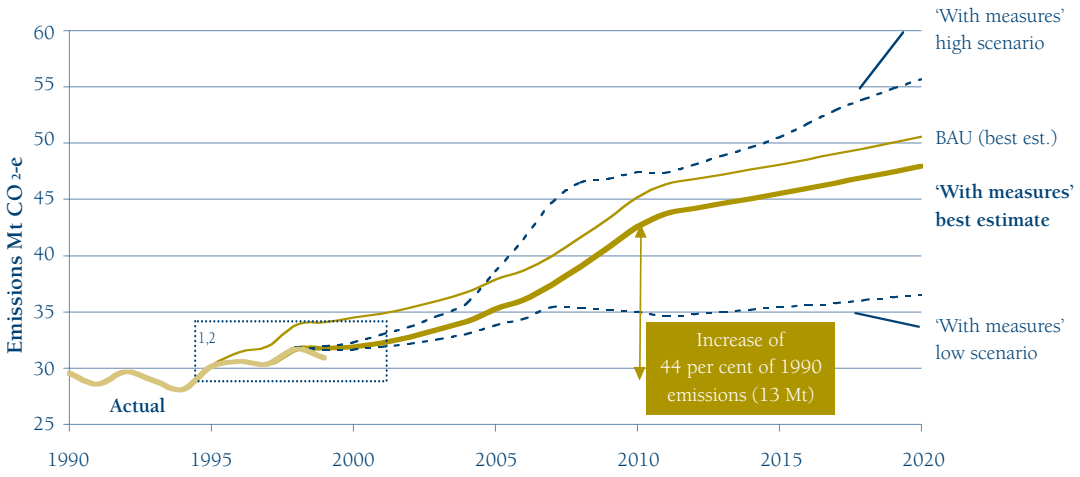
NGS Module	Measure	Mt Saving in 2010
5.10	Environmental Strategy for the Motor Vehicle Industry	2.0
5.12	Diesel and Alternative Fuel Grants Scheme	Included in BAU
5.12	Alternative Fuels Conversion Program	Included with CNG infrastructure
5.12	Compressed Natural Gas (CNG) infrastructure program	0.5
Various	Additional State and Territory actions under the NGS[1]	1.4
Total Transport sector		**3.9**

1. This estimate includes additional action under NGS 5.2, 5.7 and 5.9.

Projections of Fugitive sector emissions

The Fugitive Emissions sector covers methane (CH_4), carbon dioxide (CO_2) and nitrous dioxide (N_2O) emissions from the production, processing, transport, storage, transmission and distribution of raw fossil fuels, but does not cover the emissions from fuel burnt for process energy.

Figure 5.3 Emissions from the Fugitive Emissions sector, 1990 to 2020



1. The projections are based on 1998 data, thus the 'with measures' projections match the 1998 actual emissions. Inventory emissions in 1999 fall below the projected emissions for 1999.
2. Fugitive abatement measures have been implemented since 1995, so there is a divergence between business as usual and actual (which represents 'with measures' emissions) at that point.

Factors influencing sectoral emission projections

Significant improvements have been made in reducing ventilation of waste coalmine gas since 1995. Rapid growth in emissions to 2010 results from projected increases in production of coal, oil and gas. The Fugitive Emissions sector is particularly dependent on expectations about the implementation of major projects.

Analytic approach followed

The BAU projection is an average of a top down (ABARE's GTEM) and a bottom up projection (Energy Strategies). The GTEM projection is consistent with the projection for all other energy sectors.

Assumptions

Assumed levels of production of coal, oil and gas are provided in Table 5.4.

Table 5.4 Increase in coal, oil and gas production

	2000 % growth from 1998	2010	2020
Coal	4.6 to 5.5	24.1 to 27.2	43.5 to 44.4
Oil	-0.1	-0.6	-1.1
Gas	9 to 11	103 to 113	122 to 157

Business as usual projections

Emissions from the Fugitive Emissions sector in 2010 are projected to be 45.1 Mt CO_2-e under business as usual (range of 37.6 to 50.0 Mt CO_2-e). This represents 153% (range of 127 to 169%) of 1990 levels (29.5 Mt CO_2-e).

Effects of policies already in place ('with measures')

The impact of measures is estimated to be 2.6 Mt CO_2-e for a 'with measures' projection of 42.5 Mt CO_2-e in 2010, which represents an increase of 44% over 1990 levels. The emissions projection range for this sector is shown in Figure 5.3. A list of measures and impacts is provided in Table 5.5.

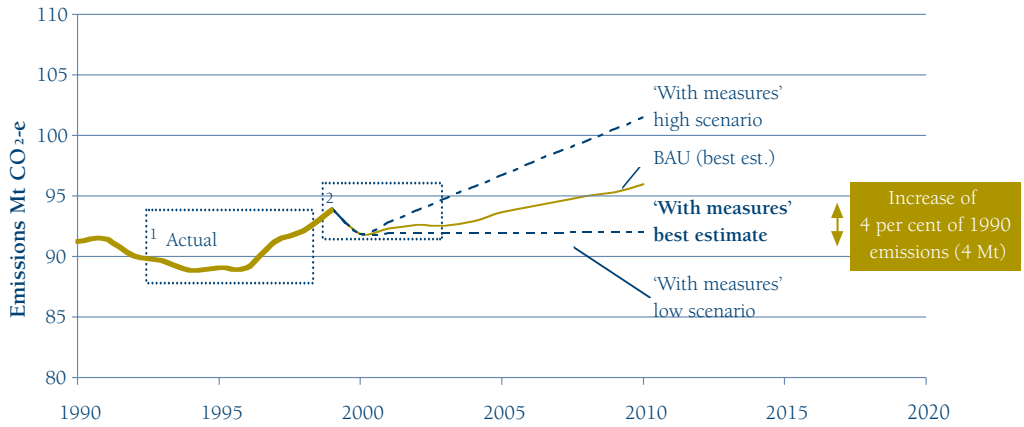
Table 5.5 Total N_2O emissions by sector, 1990 to 2000

NGS Module	Measure	Mt Saving in 2010
7.1	Greenhouse Challenge (Coal emissions)	2.3
7.1	Greenhouse Challenge (Oil and Gas emissions)	0.3
Total Fugitive sector		**2.6**

Projections of Agriculture sector emissions

Sources of greenhouse gas emissions from the Agriculture sector under the UNFCCC classification of agriculture include non-CO_2 gases only from enteric fermentation from livestock, manure management, rice cultivation, agricultural soils, prescribed burning of savannas and field burning of agricultural residues.

Figure 5.4 Emissions from the Agriculture sector, 1990 to 2020



1. The 1990s were a period of low (sometimes negative) growth in agricultural activity. Livestock numbers were depressed. The collapse of the wool price scheme after 1990 reduced sheep numbers by 33%.
2. In 1998 and 1999 there was a higher than usual rate of savanna burning, which is not projected to continue. The projection uses the historic average for savanna burning (prescribed burning excluding natural bushfires), which results in the sharp drop to 2000. Further research is required to improve this methodology.

Factors influencing sectoral emission projections

Agriculture emissions are dominated by livestock and subject to fluctuations in climate and international trade conditions. Emissions from livestock are projected to grow slowly from recent high levels to 2010 in line with a positive outlook for Australian agricultural exports. Projections for the Agriculture sector are highly uncertain in the long term, therefore no projection is provided between 2010 and 2020, even though the projections of one model (the Global Meat Industry (GMI) model – see below) extends across that period.

Analytic approach followed

The most recent projections of greenhouse gas emissions for the agricultural sector use projections of agricultural activity from two bottom up models, the ABARE Aglink model and the CIE GMI model.

Assumptions

Table 5.6 Key assumptions for the Agriculture sector

Assumption	Source	Range
Countries within the OECD-GDP growth	Annual %	2.1 to 5.6
Countries not in the OECD-GDP growth	Annual %	2.7 to 7.6
Rest of world population growth[1]	Annual %	1.0 to 1.3
Australian beef export growth (2000 to 2010)	Annual %	0.8 to 2.2
Exchange rate (2010)	$US/$AUS	0.69 to 0.70

1. CIE and ABARE use differing regional coverage.

Business as usual projections

Emissions from the Agriculture sector in 2010 are projected to be 95.9 Mt CO_2-e under BAU (range of 92 to 102 Mt). This represents 105% (range of 101 to 112%) of 1990 levels (91.2 Mt).

Table 5.7 Key agriculture results

Assumption	Source	1990	2010	2020
Cattle numbers	ABARE 2001	24.9	26.5	na
(million head)	CIE 2001		28.3	31.6
Sheep numbers	AGLINK 2001	173	124	na
(million head)	CIE 2001	122	126	
Wheat	ABARE 1999	9.2	11.5	10.7
(million ha)				

na not available

Effects of policies already in place ('with measures')

The impact of measures is estimated to be 1.1 Mt CO_2-e for a 'with measures' projection of 94.8 Mt CO_2-e in 2010, which represents an increase of 4% over 1990 levels. The emission projection range for this sector is shown in Figure 5.4. A list of measures and impacts is provided in Table 5.8.

Table 5.8 Impact of current measures in the Agriculture sector in 2010

NGS Module	Measure	Mt Saving in 2010
6.9	Residue Burning	0.1
6.9	Nitrification inhibitor	0.02
6.9	Reduced fertiliser application	0.9
6.9	Waste management	0.05
Total Agriculture sector		1.1

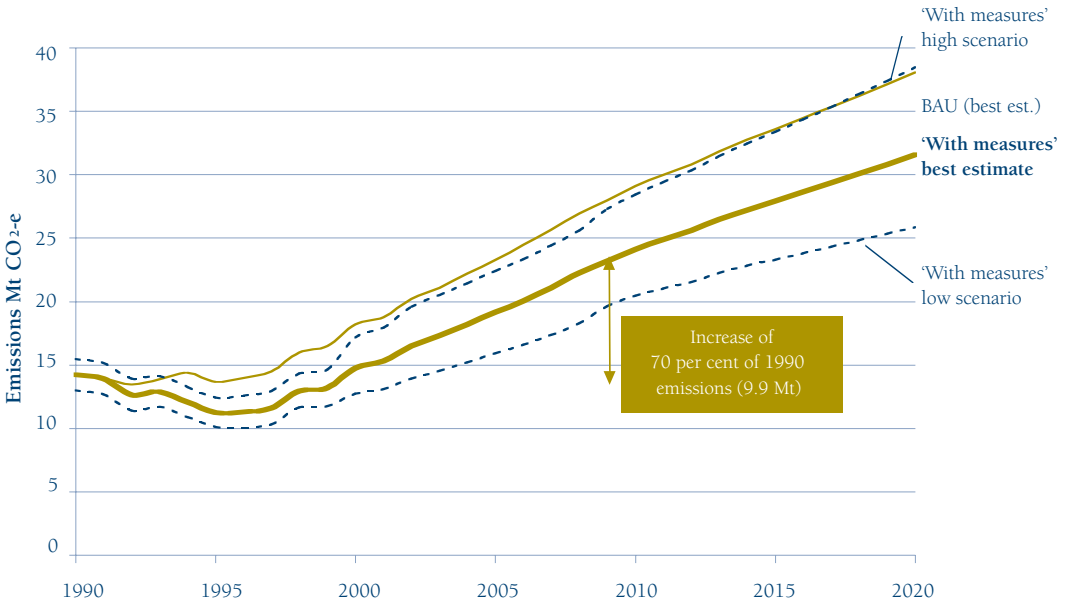
Projections of Industrial Processes sector emissions

The Industrial Processes sub-sectors include greenhouse gas process emissions from the following areas:

- mineral products (cement clinker production, lime production, limestone and dolomite use, soda ash production and use);
- nitric acid production;
- metals production (iron and steel, aluminium and sulphur hexafluoride (SF6) used in magnesium foundries);
- industries covered by the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol) (refrigeration and air-conditioning, foam blowing, fire extinguishers, propellants and solvents); and
- SF_6 used in circuit breakers and switchgear.

Non process greenhouse gas emissions and abatement from the above industries (for example emissions and abatement of energy used in industrial processes) are counted in other sectors in accordance with the definitions used in the National Greenhouse Gas Inventory.

Figure 5.5 Emissions from the Industrial Processes sector, 1990 to 2020[1]



1. The range for the period 1990 to 1999 reflects the current uncertainty surrounding historic emissions of SF_6 used in electrical switchgear and circuit breakers. SF_6 and hydrofluorocarbons (HFCs) are yet to be included in the National Greenhouse Gas Inventory, so there is no actual emissions line shown.

Factors influencing sectoral emission projections

The decline in emissions to 1995 (which derived from abatement of perfluorocarbon (PFC) emissions in the aluminium production process) is reversed from the late 1990s due to the phasing out of ozone depleting substances under the Montreal Protocol, which are replaced with hydrofluorocarbons (HFCs) covered by the Kyoto Protocol. Growth in emissions after 2000 is in line with projected growth in population and gross domestic product.

Analytic approach followed

Simple trend analysis for each industry was undertaken by Burnbank Consulting, then coupled with industry advice.

Assumptions

Detailed assumptions by industry and product type leading to overall estimate. Population and GDP assumptions see Table 5.1.

Business as usual projections

Emissions from the industrial processes sector in 2010 are projected to be 29.1 Mt CO_2-e under BAU (range of 24.7 to 34.2 Mt). This represents 242% (range of 206 to 285%) of 1990 levels (12.0 Mt).

Effects of policies already in place ('with measures')

The impact of measures is estimated to be 4.9 Mt CO_2-e (4.3 to 5.7 Mt) for a 'with measures' projection of 24.1 Mt CO_2-e (20.4 to 28.4 Mt) in 2010, which represents 201% (range of 170 to 237%) of 1990 levels. The emission projection range for this sector is shown in Figure 5.5. A list of measures and impacts is provided in Table 5.9.

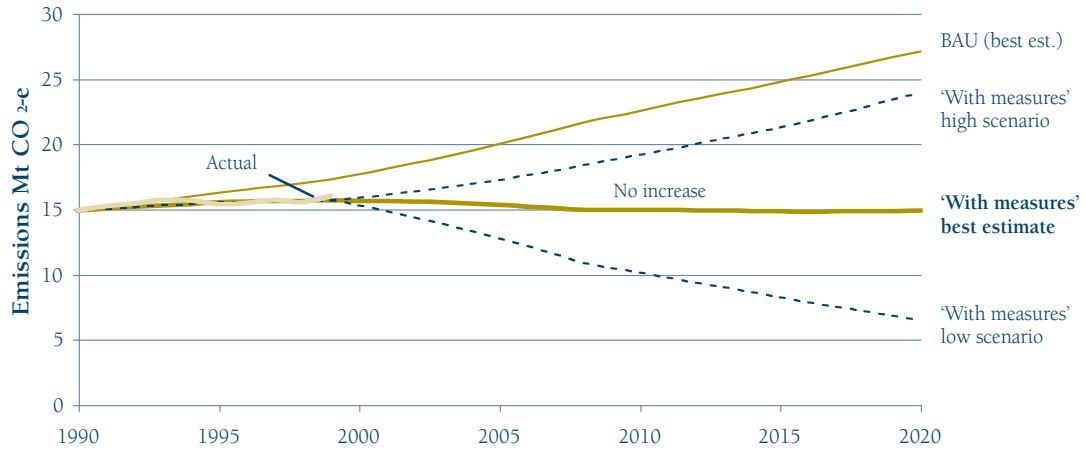
Table 5.9 Impact of current measures in the Industrial Processes sector in 2010

	Mt Saving in 2010
Total Industrial Processes sector (includes PFC reductions)	4.9

Projections of Waste sector emissions

The Waste sector covers emissions from solid waste disposal on land (including municipal solid waste), domestic, commercial and industrial wastewater treatment and waste incineration. The primary greenhouse gas emitted is CH_4. The gases CO_2 and N_2O are also emitted.

Figure 5.6 Emissions from the Waste sector, 1990 to 2020



Factors influencing sectoral emission projections

Population growth (domestic waste) and GDP (domestic and commercial waste) are the main drivers of emissions from this sector. Significant improvements in landfill management and waste recovery management are projected to keep emissions at historic levels.

Analytic approach followed

Projections were based on a single projection developed in 2001 by specialised consultants (Meinhardt (Vic) Pty Ltd).

Assumptions

Although the main drivers of emissions in this sector have increased (gross domestic product and population, see Table 5.1) increasing diversion of organic solid waste under BAU and the relatively large impact of other measures has kept the level of emissions constant for this sector.

Business as usual projections

Emissions from the waste sector in 2010 are projected to be 22.9 Mt CO_2-e under BAU (range of 22.2 to 24.1 Mt). This represents 154% (range of 150 to 162%) of 1990 levels (14.9 Mt).

Effects of policies already in place ('measures')

The best estimate of the impact of measures is 8.0 Mt CO_2-e for a 'with measures' projection of 14.9 Mt CO_2-e in 2010, which represents no increase over 1990 levels. The emission projection range for this sector is shown in Figure 5.6. A list of measures and impacts is provided in Table 5.10.

Table 5.10 Impact of current measures in the Waste sector in 2010

NGS Module	Measure	Mt Saving in 2010
7.3, 7.4, 7.5	State and Territory actions under NGS	7.7
Total Waste Sector		7.7

Projections of Land Use Change and Forestry sector emissions

The Land Use Change and Forestry sector is sub-divided into the Forestry and Other sub-sectors and the Land Use Change (forest conversion) sub-sector.

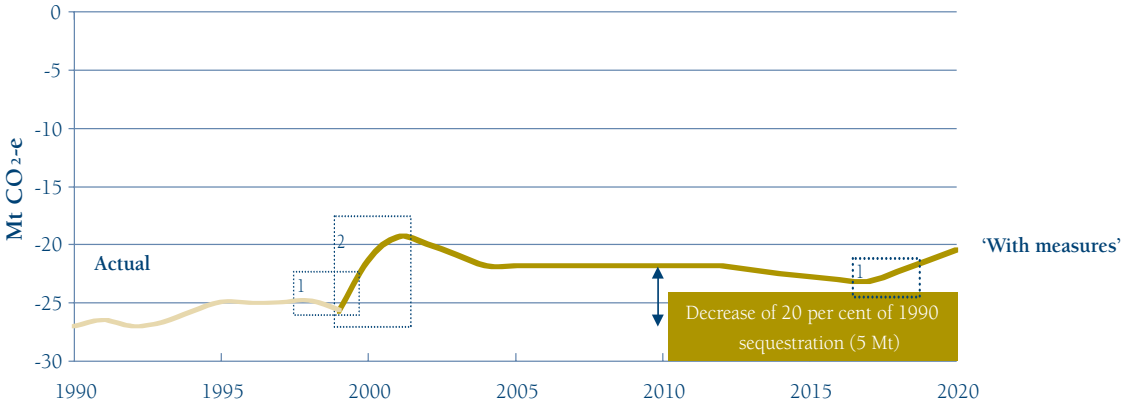
Emissions/sequestration for this sector were previously highly uncertain due to significant limitations in data and methodology. Application of the full suite of datasets and the spatial modelling capability of the National Carbon Accounting System (NCAS) has now provided robust best estimates for emissions from past Land Use Change. Extrapolation of recent average Land Use Change emissions is the basis for projections and these will be further improved in the future. NCAS is also expected to provide robust estimates for past emissions and removals from the Forestry sub-sector in 2003, after which improved projections will be developed for this sub-sector.

Forestry and Other sub-sectors under UNFCCC accounting

Forestry and Other covers commercial forestry operations and environmental tree planting in Australia, sequestration of carbon in agricultural soils, and prescribed burning of forests and wildfires. The projections presented below are indicative only.

The projections provided in this section are for the Forestry sub-sector as defined by the UNFCCC inventory reporting guidelines (referred to as 'UNFCCC accounting') 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 the Kyoto Protocol afforestation and reforestation activity is treated as having zero accounted sequestration prior to 2008 – 2012. The impact of this difference is significant in that when calculating the growth in emissions, the level of emissions projected for 2010 is compared with a lower base year under the UNFCCC than occurs under the Kyoto rules, and new forest plantations enter the emissions accounts as credits.

Figure 5.7 Emissions/sequestration from the Forestry and Other sub-sectors, 1990 to 2020 (UNFCCC accounting)



1. The National Greenhouse Gas Inventory records a rapid expansion in plantations in the late nineties leading to an increase in sequestration. The harvest of these forests is seen in the latter part of the projection period.
2. Areas of significant conservation value have been excised from commercial native forests under the Regional Forest Agreements. This reduces the area of commercial native forest and therefore reduces the area eligible for claiming sequestration under the UNFCCC guidelines.

Factors influencing sub-sectoral emission 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.

Business as usual projections

BAU emissions are not provided. Forestry and Other is calculated as a 'with measures' value as not all measures have been estimated to allow calculation of business as usual. High and low scenarios have not been quantified.

Effects of policies already in place ('measures')

Overall, the 'with measures' projection for the Forestry and Other sub-sectors is for an indicative 22 Mt CO_2-e of sequestration in 2010, a reduction of approximately 5 Mt CO_2-e compared with 1990 levels of sequestration (Figure 5.7). As noted above, this UNFCCC outcome is different to that relevant under the Kyoto Protocol.

The above estimate includes an indicative estimate of the impact of measures to increase environmental plantings of 3.9 Mt CO_2-e of sequestration in 2010 (Table 5.11). The impacts of a range of other measures in the Forestry and Other sub-sectors have not been assessed.

The National Carbon Accounting System results for Forestry, expected in 2003, will provide more robust estimates of sequestration and emissions from forest sinks and the impact of measures in the sub-sector.

Table 5.11 Impact of current measures in the Forestry and Other sub-sectors in 2010[1]

NGS Module	Measure	Mt Saving in 2010
6.2	Environmental plantings under the Natural Heritage Trust and other programs	3.9

1. Indicative estimate for environmental plantings only. Not all measures have been estimated.

Forestry under Kyoto rules

Under Kyoto accounting rules, no forestry sinks are included in the 1990 baseline. Only greenhouse sinks credits from afforestation and reforestation activities (occurring since 1 January 1990 on land not previously forested) count towards achievement of the Kyoto target.

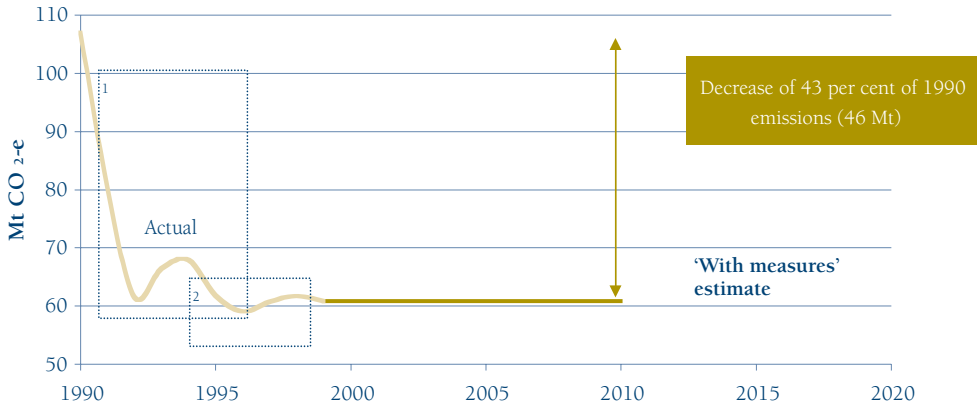
Current projections are for approximately 21 Mt CO_2-e per year to be sequestered under the Kyoto rules for afforestation and reforestation over 2008-2012. This estimate will undergo improvement with future work of the National Carbon Accounting System.

Land Use Change sub-sector

Deforestation is included in the emissions accounts for both 1990 and 2008-2012 under the Kyoto Protocol rules applying to Australia and equivalent to the Land Use Change sub-sector under the UNFCCC guidelines.

Based on results from the National Carbon Accounting System, CO_2 emissions from the Land Use Change sub-sector are estimated at 107 Mt CO_2 in 1990, before falling in the subsequent years to 1999 (Figure 5.8). Current emissions projections are based on the simple extrapolation of recent average Land Use Change emissions, and therefore have high uncertainty. As a result, the estimates only extend to 2010. High and low scenarios have not yet been estimated.

Figure 5.8 Emissions[3] from the Land Use Change sub-sector, 1990 to 2010



1. The NCAS reports a fall in Land Use Change emissions over the early 1990s.
2. Projections are a simple 'straight-line' extrapolation of emissions over the four years 1995-98.
3. Projections are for CO_2 only – the dominant component of emissions. The minor non-CO_2 emissions components will be developed following further analysis.

Factors influencing sub-sectoral emission projections

Estimates of Land Use Change emissions depend on 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.

Business as usual projections

The BAU projection for the Land Use Change sub-sector is an indicative 61 Mt CO_2 in 2010.

Effects of policies already in place ('measures')

The impact of measures has not yet been estimated, so that the 'with measures' projection is the same as the BAU projection. This is a conservative estimate of the performance of greenhouse measures as it does not include some recent State and Territory vegetation management regulations and the National Action Plan for Salinity and Water Quality.

Projections of Greenhouse Gas Abatement Program emissions abatement

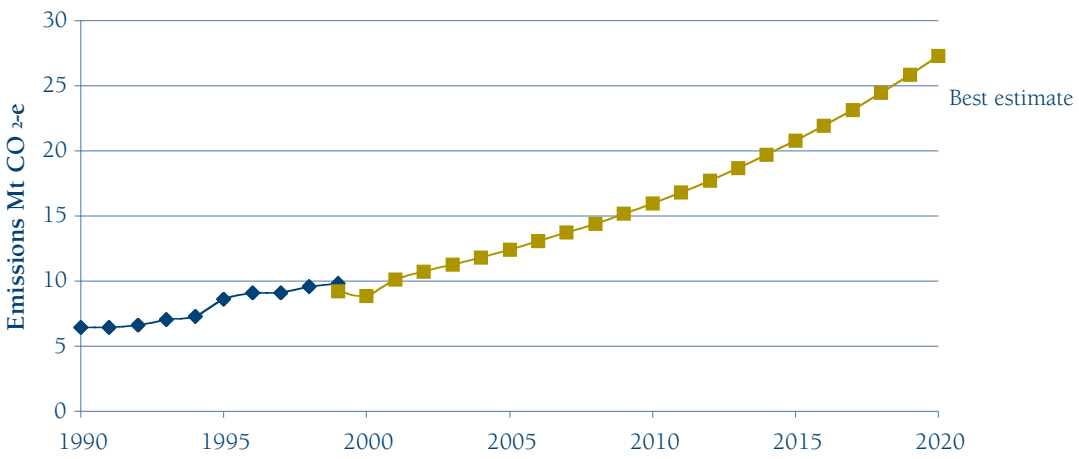
The Greenhouse Gas Abatement Program (GGAP) (see *Chapter 4 – Policies and Measures*) is estimated to create approximately 10.8 Mt CO_2-e of abatement in 2010 based on a cost of abatement under the program of between $4 and $8 dollars of GGAP funding per tonne, reflecting the results from Round 1 of funding. The 10.8 Mt CO_2-e estimate allows for administration costs, investment in research and development and a contribution to policy development aimed at increasing abatement.

The range of possible outcomes is 10 Mt CO_2-e to 12 Mt CO_2-e based on the potential for additional low cost abatement, but noting the possibility that future rounds of GGAP funding may not achieve the same levels of abatement as Round 1. It is intended to revise the GGAP estimate once deeds of agreement with proponents are finalised.

Projections of international bunker fuels emissions

International bunker fuels relate to fuels used for the purpose of international trade and travel between Australia and other nations. Emissions from this sector are projected to more than double over the period 1990 to 2010 (increase of 247%, see Figure 5.9). The large increase is a result of rapid projected growth in trade and international travel. There are no measures targeted at this sector. Emissions from international bunker fuels are not counted in the total emissions for Australia.

Figure 5.9 Emissions from international bunker fuels, 1990 to 2020



Projections by gas

Table 5.12 Emissions estimates by sector by gas, 'with measures' (Mt CO_2-e) (UNFCCC accounting)[1]

		Stationary Energy	Transport	Fugitive	Agriculture	Waste Processes	Industrial	GGAP[2] – all sectors	Land Use Change and Forestry[3,4]
1990									
	CO_2	206.0	59.2	6.7	na	ne	6.7	na	78.1
	CH_4	1.7	0.6	22.8	72.1	14.9	0.1	ne	6.8
	N_2O	0.8	1.6	0.0	19.1	ne	0.5	ne	1.0
	PFCs	na	na	na	na	na	4.8	ne	na
	SF_6[5]	na	na	na	na	na	1.0	ne	na
	HFCs[5]	na	na	na	na	na	1.1	ne	na
1995									
	CO_2	223.2	64.8	6.5	na	0.0	7.0	na	35.2
	CH_4	1.9	0.5	23.6	69.1	15.5	0.1	ne	4.8
	N_2O	0.9	3.1	0.0	19.9	ne	0.4	ne	0.8
	PFCs	na	na	na	na	na	1.4	ne	na
	SF_6[5]	na	na	na	na	na	1.3	ne	na
	HFCs[5]	na	na	na	na	na	1.0	ne	na
2000									
	CO_2	257.2	70.7	6.7	na	0.0	8.0	na	32.8
	CH_4	2.1	0.5	25.1	72.9	15.6	0.1	ne	4.5
	N_2O	1.0	4.1	0.0	21.0	ne	0.7	ne	0.7
	PFCs	na	na	na	na	na	1.0	ne	na
	SF_6[5]	na	na	na	na	na	1.6	ne	na
	HFCs[5]	na	na	na	na	na	3.3	ne	na
2005									
	CO_2	269.5	78.7	7.4	na	0.0	9.2	-6.5	38.9
	CH_4	2.2	0.5	27.8	72.2	15.3	0.1	ne	ne
	N_2O	1.1	5.1	0.0	20.8	ne	0.7	ne	ne
	PFCs	na	na	na	na	na	0.9	ne	na
	SF_6[5]	na	na	na	na	na	1.9	ne	na
	HFCs[5]	na	na	na	na	na	6.4	ne	na
2010									
	CO_2	281.0	84.6	8.9	na	0.0	10.2	-10.8	38.8
	CH_4	2.3	0.4	33.6	73.6	14.9	0.1	ne	ne
	N_2O	1.1	5.7	0.0	21.2	ne	0.8	ne	ne
	PFCs	na	na	na	na	na	0.9	ne	na
	SF_6	na	na	na	na	na	2.0	ne	na
	HFCs	na	na	na	na	na	10.2	ne	na
2015									
	CO_2	299.7	90.6	9.6	na	0.0	11.5	-11.4	ne
	CH_4	2.5	0.5	35.9	ne	14.8	0.1	ne	ne
	N_2O	1.2	5.9	0.0	ne	ne	0.8	ne	ne
	PFCs	na	na	na	na	na	1.0	ne	na
	SF_6	na	na	na	na	na	2.1	ne	na
	HFCs	na	na	na	na	na	12.5	ne	na
2020									
	CO_2	321.2	97.1	10.1	na	0.0	12.9	-12.0	ne
	CH_4	2.6	0.5	37.8	ne	14.8	0.1	ne	ne
	N_2O	1.3	6.3	0.0	ne	ne	0.8	ne	ne
	PFCs	na	na	na	na	na	1.1	ne	na
	SF_6	na	na	na	na	na	2.2	ne	na
	HFCs	na	na	na	na	na	14.5	ne	na

ne Not estimated.
na Not applicable.

1. The estimates reported here are consistent with Table 5.13. With the exception of LUCF, they are based on the 1999 Inventory, and differ from the 2000 Inventory estimates reported in *Chapter 3 – National Greenhouse Gas Inventory*.
2. The Greenhouse Gas Abatement Program.
3. These forestry estimates are different to the reforestation estimates relevant under the Kyoto Protocol.
4. The LUCF inventory estimates are from the 2000 Inventory. Projections for Land Use Change extend to 2010 only. Projections for the Forestry and Other sub-sectors are not disaggregated by gas.
5. These are indicative estimates not included in the National Greenhouse Gas Inventory.

ASSESSMENT OF AGGREGATE EFFECTS OF POLICIES AND MEASURES

Emissions projections across all sectors have undergone a process of continuous improvement since Australia's *Second National Communication* in late 1997. Further work is in train to build on these estimates. In particular, a major investment in Land Use Change and Forestry sector methods and data is reaching fruition, and will produce sound estimates of emissions and removals for the National Greenhouse Gas Inventory and projections.

Current BAU and 'with measure' projections have been developed for the Stationary Energy, Transport, Fugitive Emissions, Agriculture, Industrial Processes and Waste sectors. Projections for the Land Use Change and Forestry sector have been developed on an indicative 'with measures' only basis. The emissions projections estimates includes Land Use Change emissions that were previously omitted from Australia's projections due to high uncertainty.

According to the UNFCCC accounting arrangements and with all sectors and greenhouse gas abatement measures included, Australia's total emissions are projected to grow by 16% (82 Mt CO_2-e) to 580 Mt CO_2-e between 1990 and 2010 (Table 5.13). This UNFCCC projection differs significantly from a projection under the Kyoto accounting provisions, which apply to Australia's target of 108% over the period 2008–2012 relative to 1990 levels, particulary with regard to treatment of forest sinks.

Assessment of Australia's emissions projections according to Kyoto Protocol rules indicates that between 2008-2012, emissions would be 111% of 1990 levels on average.

These emissions projections are a best estimates; more analysis is being undertaken to quantify uncertainty and develop plausible scenarios for high and low bounds around the best estimate.

Currently implemented measures in the Energy, Industrial Processes, Waste and Agriculture sectors combine to total 59 Mt CO_2-e at 2010. That is, for those sectors emissions are reduced from 600 Mt CO_2-e under BAU, to 541 Mt CO_2-e 'with measures'.

Australia's total emissions in 2000 are estimated to be about 6% above 1990 levels on a UNFCCC accounting basis, and about 5% according to the Kyoto accounting rules that apply to Australia's 108% emissions target.

Main sectoral contributions

Sectoral contributions to total emissions are dominated by energy, agriculture and land use change and forestry (Table 5.13).

- The Energy sector (comprising stationary energy, transport and fugitive) continues to be the most significant source of greenhouse gas emissions (approximately 72% of total emissions in 2010).
- Agriculture emissions are not projected to grow significantly, but will still contribute approximately 16% of emissions in 2010.
- Industrial process emissions are expected to grow rapidly, but from a small base. They contribute approximately 4% of projected emissions in 2010.
- The contribution of the Waste sector shrinks slightly as emissions are maintained at 1990 levels.

- On a UNFCCC accounting basis, the Forestry and Other sub-sectors is expected (according to indicative projections) to sequester approximately 22 Mt CO_2-e (4% of total net emissions) in 2010. On the same basis, Forestry and Other is estimated to have sequestered approximately 27 Mt CO_2-e (5% of total net emissions) in 1990. The Kyoto target implementation provisions are different – on this basis new forest plantations provide around 21 Mt CO_2 removals annually over 2008–2012.
- Emissions from the Land Use Change sub-sector are projected to be 61 Mt CO_2 (10% of total net emissions) in 2010 (based on preliminary estimates). The sub-sector is estimated to have emitted approximately 107 Mt CO_2 (21% of total net emissions) in 1990.

Table 5.13 Net greenhouse gas best estimate emission projections, 1990 and 2010 (UNFCCC accounting)

	1990[1,2]	2010 Business as usual		Measures[3]	2010 'with measures'	
	Mt CO_2-e	Mt CO_2-e	% of 1990	Mt CO_2-e	Mt CO_2-e	% of 1990
Energy	299	453	151	35	418	139
Stationary	*209*	*313*	*150*	*28*	*284*	*136*
Transport	*61*	*95*	*154*	*4*	*91*	*148*
Fugitive	*30*	*45*	*153*	*3*	*43*	*144*
Agriculture	91	96	105	1	95	104
Waste	15	23	152	8	15	100
Industrial Processes	12	29	242	5	24	201
Impact of GGAP[4]				11	-11	
Sub total	418	600	144	59	541	130
Land Use Change[5] and Forestry[6]	80	ne	ne	ne	39	49
Land Use Change[5]	*107*	*ne*	*ne*	*ne*	*61*	*57*
Forestry[6] & Other	*-27*	*ne*	*ne*	*ne*	*-22*	*81*
Total[7]	**498**	**ne**	**ne**	**59**	**580**	**116**

1. Note that the total emissions for 1990 would be different for the Kyoto target baseline, because of different rules for forestry sinks.
2. With the exception of the Land Use Change and Forestry sector, the 1990 estimates utilised for developing projections were from the 1999 National Greenhouse Gas Inventory. These are slightly different from the 2000 estimates used in *Chapter 3 – National Greenhouse Gas Inventory*.
3. Details of measures are provided in the preceding sections.
4. The total estimated abatement from the Greenhouse Gas Abatement Program. Impacts occur in a range of sectors.
5. Land Use Change projections are for CO_2 only.
6. Forestry as defined under the UNFCCC includes all commercial forestry activity and environmental tree planting in Australia. The Kyoto Protocol accounting provisions for new (post–1990) forest plantations are different and are not shown in Table 5.13.
7. Columns may not sum to totals due to rounding.

ne Not estimated.

Reconciliation to previous projections

The projections included in Australia's Second National Communication submitted in 1997 projected 28% increase in emissions between 1990 and 2010. However, this did not include measures in the Prime Minister's 1997 Safeguarding the Future package of measures. When these measures were included, the projected increase in emissions was 18% between 1990 and 2010. The projections in 1997 were incomplete as they excluded Land Use Change emissions.

For purposes only of reconciling past and current projections estimates, the growth in emissions in the current estimates with Land Use Change excluded for comparison with the 1997 estimate is 33% (Table 5.14). This reflects higher projected emissions under BAU, a reduction in the expected impact of measures and analysis of double counting effects. Corrections to the 1990 figures relate to improvements in data and methodology for inventory purposes. Inclusion of Land Use Change emissions in the current estimates complete the 1990 emissions baseline and in the reconciliation exercise reduce the rate of 2010 emissions growth relative to 1990, from 33% to 16% (Table 5.14).

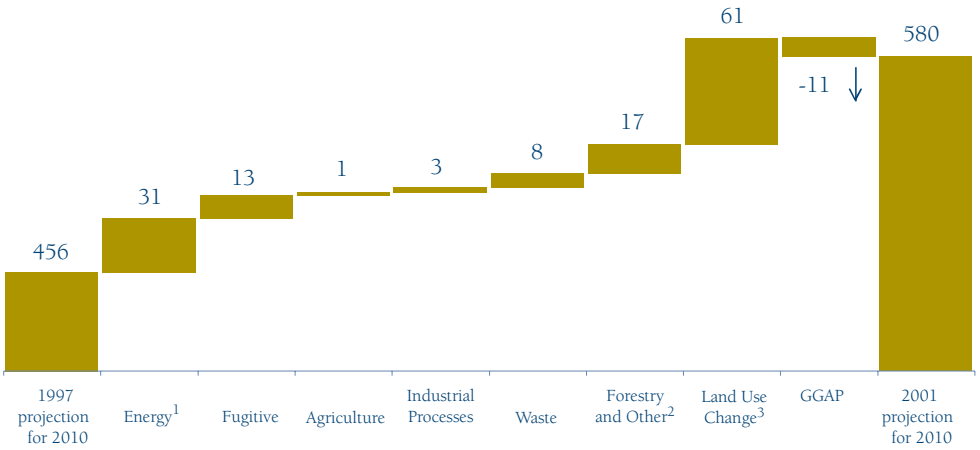
A sectoral breakdown of the increase in emissions from the 1997 projection (including additional measures) to the current projection is shown in Figure 5.10. The introduction of the Greenhouse Gas Abatement Program provides some offset to the changes in the projected emissions in 2010 in other areas.

Table 5.14 Comparison of projections 1997 and 2001[1,2] (UNFCCC accounting)

Projection	1990[3]	2010			
		Business as usual	Measures	'With measures'	
	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	% of 1990
Second National Communication					
As published (1997) (excl. LUC)	386	551	54	495	128
Including additional measures	386	553	96	456	118
Current projection					
Excluding LUC	390	ne	59	519	133
Including LUC	498	ne	59	580[4]	116[4]

1. Best estimate projections.
2. Includes Forestry as defined under the UNFCCC, which includes all commercial forestry activity and environmental tree planting in Australia. This differs to the forestry sinks eligible under the Kyoto Protocol.
3. Note that the total emissions for 1990 do not relate to the Kyoto target (108%) baseline.
4. Note that the projection is based on UNFCCC accounting, and does not equate with a projection for comparison with the 108% Kyoto target.

Figure 5.10 Sectoral net contributions to change in 2010 projection (Mt CO_2-e) (UNFCCC accounting)



1. Energy includes Stationary Energy and Transport.
2. The 1997 projection includes only the Forestry sub-sector while the 2001 projection also includes Soils (pasture improvement and minimum tillage) and Other (prescribed burning of forests and wildfire).
3. Inclusion of Land Use Change sector emissions in 2001 raises the projection for 2010 as shown, but lowers the overall 1990-2010 growth rate because Land Use Change emissions are included in the 1990 baseline and emssions decrease between 1990 and 2010.

PROJECTIONS METHODOLOGY

The approach to compiling projections for the various sectors follows a common general framework with minor variations from sector to sector:

- BAU activity levels were projected in the absence of policies and measures that reduce growth in greenhouse gas emissions.
- Projections of activity levels were converted into projections of emissions using emission factors.
- An assessment was made of the impact of current greenhouse gas abatement measures (described in each sector above) in reducing future emissions. Measures are only included if they have been implemented or are supported by regulation, fiscal incentive or other policy initiatives. The estimate includes measures implemented at Commonwealth, State and Territory and local government levels that have been undertaken for the purpose of greenhouse abatement.
- Where possible, measures have been allocated to appropriate sectors. This has not always been possible with GGAP.
- State and Territory actions under the National Greenhouse Strategy have been estimated and incorporated under the relevant sectors. Many measures require the support of all jurisdictions (for example, minimum energy performance standards). However, where specific State and Territory action has generated additional abatement, this is shown in aggregate at the bottom of the relevant tables.
- High and low projection ranges are estimated, based on sensitivity analysis and expert judgement. In some cases the range reflects the highest and lowest individual projections from those used to generate the best estimate.
- Diagrams show a best estimate for BAU and 'with measures'. In addition, high and low 'with-measures' projections are provided for most sectors that combine the high BAU with a small impact of measures and low BAU with a large impact of measures respectively. This is also expressed as a range for the projections at 2010 for each sector.

Effort has been made to follow good practice principles consistent with internationally accepted standards for projections. Particular reference has been made to the Organisation for Economic Co-Operation and Development (OECD) information paper, *Greenhouse Gas Emission Projections and Estimates of the Effects of Measures – Moving towards Good Practice* (1998).

- The majority of sectors now incorporate multiple models and/or data sources:
  - Many of the sectoral projections use projections from 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.
- Greater transparency has been achieved for key assumptions:
  - Key driving assumptions, such as rates of GDP and population growth, were provided by experts in modelling these factors (Table 5.1).
  - For consistency, assumptions for GDP and population were provided to specialised sectoral contractors for use in the bottom up models.
  - More detailed papers on the projection for each sector will be made available on the AGO website (**http://www.greenhouse.gov.au/policy/analysis_projections.html**) in 2002.
- Projections are reconciled to projections made in 1997.
- Steps have been taken to engage stakeholders for projections in each sector.

Uncertainties

Emission projections are inherently uncertain, involving judgements about the future of the global and national economy, policy actions affecting emissions, technological innovation and human behaviour. Consequently, while these projections are a considered view based on reasonable assumptions, the use of an alternative set of assumptions concerning the future will yield a different result.

An indication of the uncertainty for the sectors included in the projection is given by the high and low scenarios for the 'with measures' projections. These scenarios give a range of 540 to 623 Mt CO_2-e in 2010, or 109 to 125% of 1990 levels. These uncertainty ranges are constructed following UNFCCC accounting provisions, and would be different for a projections uncertainty analysis for the 108% Kyoto target.

- The low scenario combines all of the sectoral low estimates, the upper bound for GGAP abatement and the best estimate for Forestry and Land Use Change (no ranges available).
- The high scenario combines all of the sectoral high estimates, the lower bound for GGAP abatement and the best estimate for Forestry and Land Use Change (no ranges available).
- These scenarios will nevertheless understate total uncertainty as they do not include contributing uncertainty from the Land Use Change and Forestry estimates.

Projections have been developed for most sectors for the period 2010 to 2020. However, the 2010 to 2020 results are subject to high levels of uncertainty and therefore should be considered as illustrative only.

CHAPTER SIX

VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION

Australia has a wide range of climate regimes, with its land mass of 7.6 million km^2 extending from the tropics well into the middle latitudes. Apart from Antarctica, it is the world's driest continent, with a vast arid and semi-arid interior. Australia experiences large year to year variations in rainfall. Droughts and floods are common occurrences. The surrounding oceans play a large part in Australia's climate, and it is strongly influenced by the El Niño Southern Oscillation (ENSO).

This naturally occurring large climate variability needs to be taken into account in assessing the sensitivity, adaptive capacity and vulnerability of Australia's natural and human systems to climate change. However, natural systems that are already under pressure, for example from introduced pests, urban expansion, pollution and salinity, will be more vulnerable to climate change. Some of these natural systems may undergo significant and irreversible damage. For example, the ability of species with local distribution to adapt by moving may be limited by soil types and fragmentation of natural areas.

Adaptation strategies are important in complementing Australia's mitigation efforts, as climate change is likely to lead to significant adverse impacts on Australia's natural and human systems. The development and implementation of adaptation strategies will require the active involvement of all spheres of government, the private sector and the community.

Research into the impacts of global warming is continuing in Australia, including research into adaptation capacities. Most studies use climate projections indicating the likely range of changes in regional temperature and rainfall as a starting point. The studies define potential impacts on natural systems, agricultural systems, infrastructure, and human health, and point to the need for more integrated assessments. These impacts and vulnerability studies will guide the development of adaptation strategies aimed at minimising adverse effects and taking advantage of new opportunities presented by climate change. Some of the current studies incorporate adaptation options.

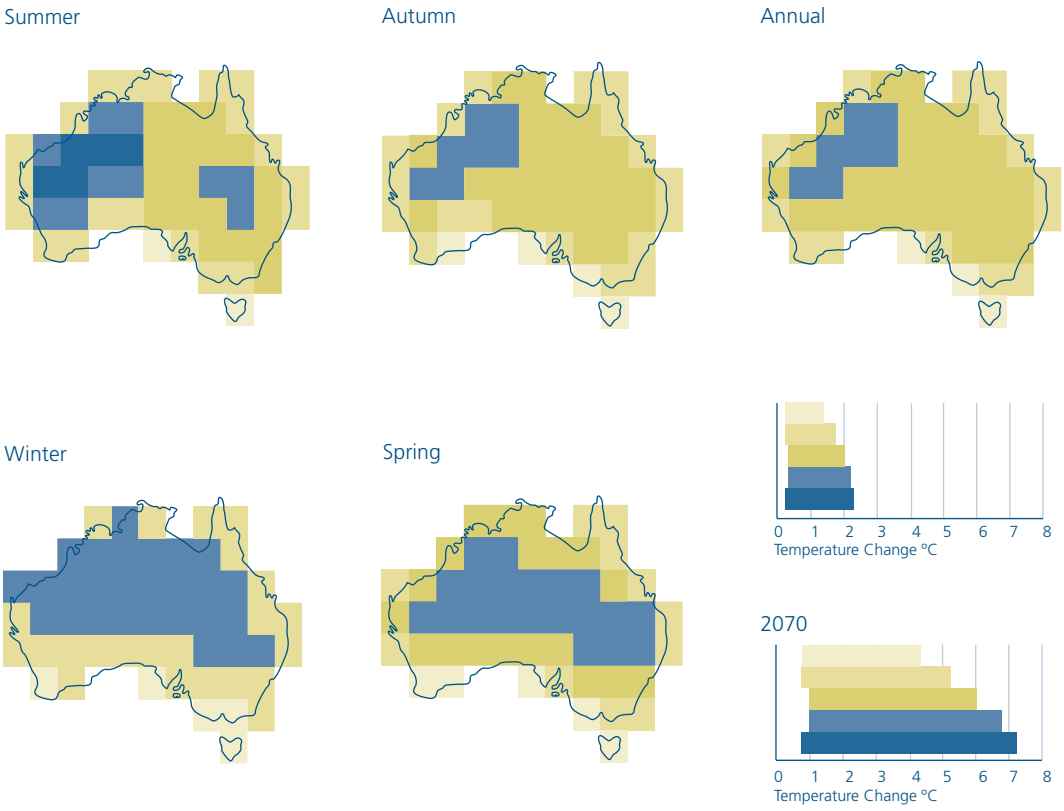
CLIMATE CHANGE PROJECTIONS

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) produces climate change projections for the Australian region using global climate model (GCM) simulations. The latest set of projections, released in May 2001 (CSIRO 2001 Projections), are based on the *Special Report on Emissions Scenarios* (2000) released by the Intergovernmental Panel on Climate Change (IPCC). They present climate averages for 2030 and 2070 relative to the average climate of 1990. The range in projections reflects the uncertainty in the amount of emissions and uncertainty in the climate system response to enhanced greenhouse gases. The projections provide a starting point for most climate impacts studies undertaken in Australia.

Temperatures

Projections of seasonal and annual temperature changes are presented in Figure 6.1. By 2030, annual average temperatures could be 0.4 to 2.0ºC higher over most of Australia, with slightly less warming in some coastal areas and Tasmania, and slightly more warming in the north-west of Australia. By 2070 average annual temperatures could be 1.0 to 6.0ºC with spatial variations similar to those for 2030.

Figure 6.1 Average seasonal and annual warming ranges (ºC) for around 2030 and 2070 relative to 1990. The coloured bars show ranges of change for areas with corresponding colours in the maps (Source: CSIRO Climate Change Projections for Australia 2001).



Changes in daily temperature ranges are expected to follow similar trends. The projected changes in extreme temperatures are given in Tables 6.1 and 6.2. The average number of days over 35ºC each summer in Melbourne could increase from 8 at present to 9-12 by 2030 and 10-20 by 2070. Conversely, the number of winter days below 0ºC in Canberra could drop from 44 at present to 31-42 by 2030 and 6-38 by 2070.

Table 6.1 Average number of summer days over 35°C at capital cities (excluding Darwin) for present conditions, 2030 and 2070 (Source: CSIRO *Climate Change Projections for Australia 2001*).

Number of summer days over 35°C			
	Present	Range in 2030	Range in 2070
Hobart (TAS)	1	1-2	1-4
Sydney (NSW)	2	2-4	3-11
Brisbane (QLD)	3	3-6	4-35
Canberra (ACT)	4	6-10	7-30
Melbourne (VIC)	8	9-12	10-20
Adelaide (SA)	10	11-16	13-28
Perth (WA)	15	16-22	18-39

Table 6.2 Average number of winter days below 0°C at selected sites for present conditions, 2030 and 2070 (Source: CSIRO *Climate Change Projections for Australia 2001*).

Number of winter days below 0°C			
	Present	Range in 2030	Range in 2070
Canberra (ACT)	44	31-42	6-38
Orange (NSW)	38	18-32	1-27
Launceston (TAS)	21	10-18	0-14
Tatura (VIC)	15	6-13	0-9
Wandering (WA)	14	5-11	0-9
Dalby (QLD)	10	3-7	0-6
Nuriootpa (SA)	9	2-7	0-5

Rainfall

Figure 6.2 shows projected ranges of change in Australian rainfall for around 2030 and 2070. Projected annual average ranges tend to decrease in the south-west of Australia (–20% to +5% in 2030 and –60% to +10% in 2070, rounded to the nearest 5%), and in parts of south-east Australia and Queensland (–10% to +5% by 2030 and –35% to +10% by 2070). In some other areas, including much of eastern Australia, projected ranges are –10% to +10% in 2030 and –35% to +35% by 2070. The ranges for the tropical north of

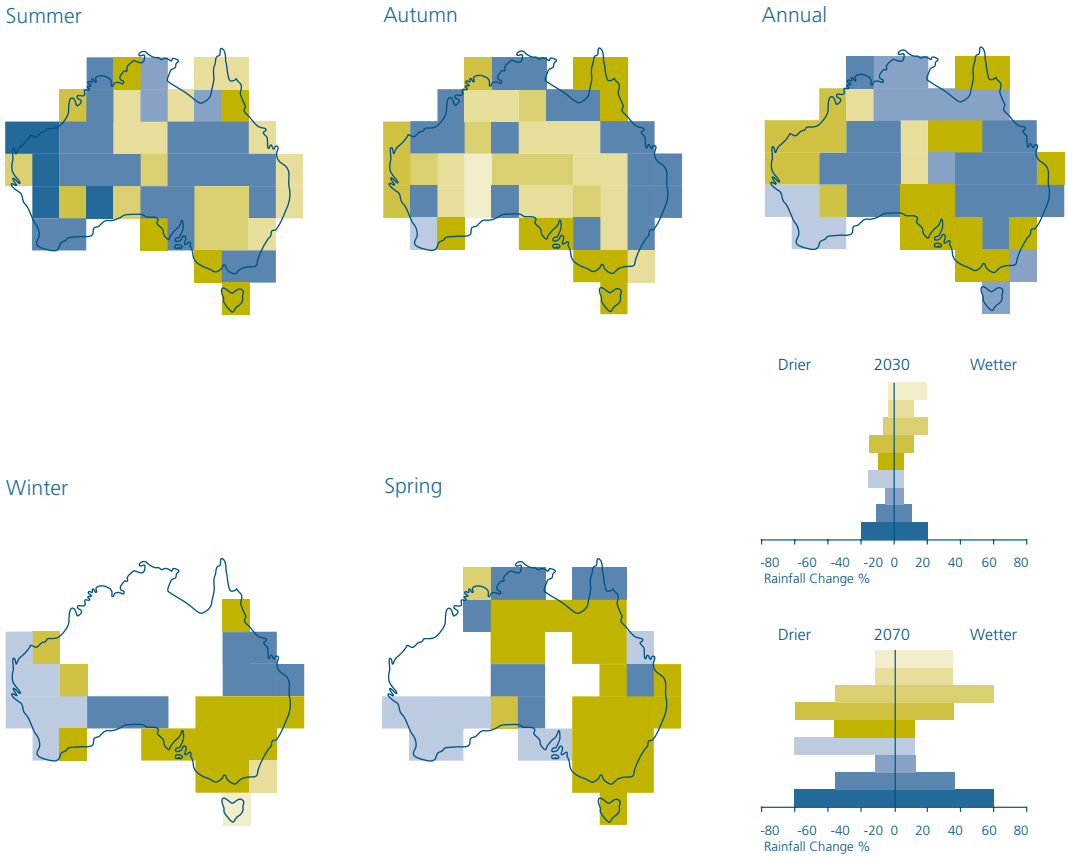
Australia (–5% to +5% by 2030 and –10% to +10% in 2070) represent little change from current conditions.

In summer and autumn, projected rainfall ranges for most locations are –10% to +10% in 2030 and –35% to +35% by 2070 or tend towards increase (–10% to +20% in 2030 and –35% to +60% in 2070). The latter occur mainly in parts of southern inland Australia in summer and inland areas in autumn. In some parts of northern and eastern Australia in summer and inland Australia in autumn the tendency for wetter conditions is –5% to +10% by 2030 and –10% to +35% by 2070. However, for the far south-east of the continent and Tasmania, projected rainfall tends to decrease in both seasons (–10% to +5% by 2030 and –35% to +10% by 2070).

In winter and spring decreased rainfall is projected for most regions (or the locations are seasonally dry). Ranges are typically –10% to +5% by 2030 and –35% to +10% in 2070. Projected decreases are stronger in the south-west (–20% to +5% by 2030 and –60% to +10% by 2070) while Tasmania shows increases in winter (–5% to +20% by 2030 and –10% to +60% by 2070).

Where average rainfall increases, more extremely wet years are projected, and where average rainfall decreases more dry spells are projected. Most models indicate an increase in extreme daily rainfall leading to more frequent heavy rainfall events. This can occur even where average rainfall decreases. Reductions in extreme rainfall occur where average rainfall declines significantly. Increases in extreme daily rainfall are likely to be associated with increased flooding.

Figure 6.2 Ranges of average seasonal and annual rainfall change (%) for around 2030 and 2070 relative to 1990. The coloured bars show ranges of change for areas with corresponding colours in the maps. Ranges are not given for areas with seasonally low rainfall because percentage changes in rainfall cannot be as reliably calculated or applied in such regions. (Source: CSIRO *Climate Change Projections for Australia 2001).*



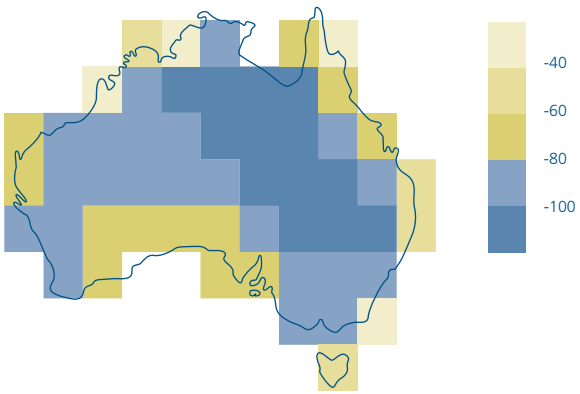
Evaporation and moisture balance

Changes in potential evaporation are included in the CSIRO 2001 Projections. These show increases annually and for all seasons of 0% to 8% per degree of global warming over most of Australia, and up to 12% over Australia's eastern highlands and Tasmania. The increases tend to be higher where there is a corresponding decrease in rainfall.

The net atmospheric moisture balance is the difference between potential evaporation and rainfall. Australia has an annual net moisture balance deficit and the environment is largely moisture limited. The simulated increases in potential evaporation and changes in rainfall indicate the overall decreases in moisture balance in Figure 6.3. Average decreases in annual water balance range from about 40 to 120 mm per degree of global warming. This represents decreases of 15 to 160 mm by 2030 and 40 to 500 mm by 2070.

The greatest consistency in the simulated changes is in spring, when the decreases are greatest over eastern Australia.

Figure 6.3 Average annual change (mm) in moisture balance for a 1°C global-average warming. The map is based on the average of eight climate model simulations. All regions experience increased moisture stress (Source: CSIRO *Climate Change Projections for Australia 2001*).



Tropical cyclones

Projections of changes in cyclone activity are difficult since tropical cyclones are not well resolved by global or regional climate models. The present indications outlined in the CSIRO regional scenarios are that:

- the regions of origin are likely to remain the same;
- maximum wind speeds may increase by 5-20% in some parts of the globe by 2100;
- preferred paths and poleward extent may alter, but changes remain uncertain; and
- future changes in frequency will be modulated by changes in the ENSO.

El Niño Southern Oscillation

The strong influence that the ENSO has in many parts of Australia will continue. The climate models do not give a consistent indication of future changes in ENSO events. However it is likely that global warming will enhance the drying associated with warm phase (El Niño) events, and enhance intense rainfall and run-off associated with cool phase (La Niña) events.

Snow cover

Global warming is expected to cause substantial reduction in the duration of winter snow cover in Australia. Modelling studies indicate that snow cover is very sensitive to changes in temperature and less sensitive to changes in precipitation. Significant snow cover is currently restricted to the Australian Alps in the south east of the continent, and parts of Tasmania, with the snow usually lasting a few weeks at elevations of 1200-1400m and for periods of up to several months higher in the mountains. Recent research has looked at how the expected reduction in snow cover will affect the sensitive alpine plant and animal communities (see below). Possible effects on the tourism industry in alpine regions have also been studied (see below), as well as the potential impacts of a reduced snow-melt on hydro-electricity production and downstream irrigation industries.

Fire danger

The incidence of wildfire in Australia is expected to increase with global warming. The number of days of extreme and high fire danger is expected to increase. Forest and grass fires are frequent in summer in Australia, sometimes causing loss of life and major property damage. An increased fire risk due to global warming may increase the associated costs.

Fire plays an important role in many Australian ecosystems. For example, it is necessary for the germination of some plants. Increases in fire frequency could have substantial effects, favouring some species at the expense of others. More frequent and intense fires may present dangers to plant communities that are not adapted to fire, such as rainforest. Australia also experiences major El Niño related bushfires, so changes to ENSO caused by global warming may be reflected in fire regimes in the ENSO-affected areas of Australia.

Sea level rise

Mean sea level is expected to increase, with local and regional variations due to land-sea movements and changes to ocean currents and climatic forcing. Local and regional meteorological events can lead to temporary fluctuations in sea level and to extreme events which may cause coastal inundation. Storm surges in tropical Australia can be several metres in height due to tropical cyclones and shallow continental shelfs. The height of the storm surge depends on the storm intensity, storm size, forward speed, timing relative to the tides, shape of the coast and slower variations such as those due to ENSO. Other issues associated with changes in sea level such as changes in wave climate and wind direction may also have far reaching effects on coastal erosion rates and inundation.

EXPECTED IMPACTS OF CLIMATE CHANGE AND VULNERABILITY ASSESSMENT

Impacts of climate change on Australia's natural environment could be significant both in themselves and for their potential economic and social flow-on effects to agriculture, infrastructure, industry and human health. The results of the impacts studies included below have generally been based on the CSIRO climate projections from November 1996. Current studies are able to use the updated projections released in May 2001.

The vulnerability of Australia's natural and human systems to climate change differs to some extent across regions within Australia. Ecosystems that are particularly vulnerable to climate change include coral reefs, arid and semi-arid habitats in south-west and inland Australia and Australian alpine systems. Increases in the intensity of heavy rains and tropical cyclones could increase the risks to human life and property and expose natural ecosystems to more flooding, storm surges, wind and erosion damage.

Australia's National Greenhouse Strategy provides for the development and implementation of a national framework for adaptation to climate change. This commitment is being progressed through the development of a Climate Change Impacts and Adaptation Work Plan that promotes cooperative action between the Commonwealth and States and Territories in relation to climate change impact research, communication of research results, and incorporation of climate change issues in relevant policies and strategies.

Some climate change impact research projects have been initiated under the Work Plan. These projects target some of the ecosystems and sectors identified in the IPCC Third Assessment Report and in the CSIRO 2001 Projections as vulnerable to climate change. The results of these studies will build on the impact studies described below.

Water supply and hydrology

Australia's water supply and hydrology systems are likely to become increasingly vulnerable to climate change due to projected drying trends over much of the continent.

Dry conditions in most parts of Australia tend to be associated with El Niño and the link between rainfall, stream flow and ENSO is statistically significant in most eastern parts. The relatively high variability in rainfall and stream flow means that the storage capacities of Australia's large dams are about six times larger than those of European dams for the same mean annual stream flow and reliability of water supply.

Decreases in stream flow seem likely for southern Australia due to reductions in rainfall, although stream flow in northern Australia may increase if summer rainfall increases. Estimated changes in stream flow in the east-central Murray-Darling Basin range from 0 to –20% in 2030 and +5 to –45% in 2070. This would result in water shortages, particularly in winter rain-fed systems that are already under stress. The regions already affected by reductions in rainfall and streamflow, mainly due to natural climate variability, would be placed under even more stress by further decline in rainfall as a consequence of global warming. Traditionally Perth, Adelaide and the inland communities are the most vulnerable to water shortages, especially during the annual dry season and drought.

Salinity is a major environmental problem in Australia, and although climate is a key factor in determining the rate of salinisation and the severity of the impacts, a comprehensive study of the effects of climate change on this problem is yet to be carried out.

Water supplies on atolls and low-lying islands in Torres Strait will be increasingly vulnerable to salt-water intrusion into ground water from rising sea-levels.

Water quality would be affected by changes in biota, water temperature, CO_2 concentration, transportation of water, sediment and chemicals, and the volume of water flow. More intense rainfall events increase the risk of flooding, and movement of chemicals and sediments in the water. Eutrophication is already a major problem in Australia and its incidence may increase with global warming. Studies under way indicate that blue-green algae can rapidly adapt to climate change conditions (light, temperature and nutrient changes) and that the distribution will increase under the climate change scenarios.

Natural systems

Many of Australia's natural systems will be vulnerable to climate change due to their limited adaptive capacity, especially those that have very small geographic ranges. Particular vulnerability factors within the Australian context include Australia's very fragile soils, which support ecosystems that are especially adapted to those soils and to the highly variable climate, as well as the prevalence of many species which have local distributions and whose adaptation by movement is limited by soil constraints and fragmentation of natural

areas. Some plant species may not be able to 'migrate' across the landscape because of soil constraints and landscape fragmentation and risk becoming endangered or extinct. Some of Australia's more vulnerable natural systems, such as coastal and interior wetlands, montane forests, mangroves and reef systems, may undergo significant and irreversible damage.

FORESTS AND WOODLANDS

In native forests and woodlands, warmer and drier conditions could threaten many eucalypt species. Eucalypts in alpine systems are particularly vulnerable to warming because they have little or no scope to retreat. A recent study of climate change impacts in woodland ecosystems in south-western Australia found that the habitats for all frog and mammal species, 28% of *Dryandra* species (a banksia-like native shrub) and one *Acacia* species in the region would be significantly reduced for a 0.5ºC warming. The study also found that for a 2ºC warming, habitats for 66% of the *Dryandra* species in the study region and all *Acacia* species in the Goldfields region of Western Australia would be eliminated.

RIVERINE AND WETLANDS

The wetlands of Australia are already under threat from reduced water flow because of dams irrigation, urban development and pollution of waterways. Climate change and sea level rise would add to their vulnerability. If sea levels rise significantly, the vast floodplains of northern Australia will be subject to significant saltwater intrusion. Riverine environments would be severely affected by reductions in rainfall. Those wetlands on the Murray-Darling Basin already affected by dams and irrigation would be placed under even more stress by a decline in rainfall.

MARINE

Coral reefs are already stressed by changes in ocean temperatures, nutrients and stream flow. Projected global warming would cause additional stress. Coral bleaching events as severe as that in 1998 may become common by 2030. Increasing cyclone intensity adds further damage. The effect of higher CO_2 levels on ocean chemistry may lead to reduced coral growth rates. Natural adaptation will probably be too slow to avert a decline in the quality of the reefs.

ALPINE

Alpine ecosystems are highly vulnerable to climate change. Less snow and shorter snow seasons appear likely. For a warming of 0.3ºC with no change in precipitation, (a low change scenario for 2030 in the alpine region), the area covered in snow contracts by 18%. If a 1.8ºC warming is accompanied by 8% less precipitation (a high change scenario for 2030) the snow area declines by 66%. These factors would reduce many alpine habitats, notably that for the Mountain Pygmy Possum.

Agriculture

Impacts of climate change on agriculture are a key concern to Australia because of this sector's importance to the national economy. In 2000/2001, agricultural exports represented a quarter of Australia's total merchandise exports. Predicting the likely impacts of climate change on agriculture is complicated because change in different climatic factors can work in different ways. Increased CO_2 boosts plant growth and increases water use efficiency, while projected increases in temperature and extreme events are likely to reduce production. Adaptation through modifying crop varieties and farm management practices can improve yields and crop value. Changes in agricultural pests will also affect the end result.

CROPS

Future wheat yields will depend on both the positive effect of increased CO_2 levels and the generally negative impacts of projected climate change. Wheat is often grown under conditions of limited water, so the beneficial effects of higher CO_2 could be particularly pronounced. However, as wheat is planted in autumn and winter and grows through to spring, any projected reductions in winter and spring rainfall over southern Australia would increase moisture stress and reduce the benefits of increased CO_2.

Studies have shown that wheat yield increases for warmings of 1-4ºC and with no change in rainfall. However, if rainfall decreases by 20%, yield would increase for up to 1ºC warming but decline for greater warmings. Higher temperatures increase the speed of crop development, reducing the time for grain-filling.

The positive response of wheat to higher CO_2 may come at the price of lower grain protein contents (9-15% reduction for a CO_2 level of 700ppm). Heat shock (reducing grain quality) will be of more concern in northern Australia.

HORTICULTURE

A projected decrease in frost frequency and severity would reduce the risk of damage to fruits that are sensitive to frost late in the growing season. However, temperate fruits that need winter chilling to ensure normal bud-burst and fruit set, are at risk of lower yields and reduced fruit quality. Stone fruit and apples in southern and elevated areas of Australia are particularly vulnerable. There is also the possibility of more hail, wind and heavy rain damage.

HIGH-RAINFALL PASTURES

The high rainfall temperate pastures of New South Wales (NSW) and Victoria are based on exotic grasses and grass-legume mixes and require fertilisation but provide high quality animal feed and give high levels of animal production. The positive impact of elevated CO_2 levels and negative impact of warming are likely to cancel each other out in this pasture zone. However, projected decreases in winter and spring rainfall in the southern regions of South Australia and Western Australia would greatly reduce plant production, significantly constraining animal production.

In the dairy industry, rising temperatures are likely to lower milk yield from cows. By 2030, annual milk losses are likely to be between 250 and 310 litres per cow, depending on the rate of warming.

RANGELANDS

Nearly three-quarters of Australia is rangeland – arid and semi-arid land where the rainfall is too low or too variable to support cropping. Cattle and sheep grazing are the main land uses. Rangelands are ecologically important because of their high species diversity and unique ecosystems.

If rainfall decreases in southern Australia by more than 10% in winter and spring – the main growing season for pastures in this area – forage and animal production would decline, despite the benefits of higher levels of CO_2. In monsoonal northern Australia, with little projected change in summer rainfall (the main growing season for pastures in that area), higher CO_2 levels should have a positive impact on plant production in these areas, but these pastures are already severely nutrient limited. Decreases in forage quality may reduce some of the potential animal production benefits in the monsoonal region. Over 40% of the Australian cattle herd graze on tropical and sub-tropical pastures in Queensland in non-monsoonal areas that are strongly affected by ENSO. Rainfall change scenarios indicate a considerable uncertainty in direction and magnitude and hence the impact on production is unknown. A substantial decline (>15%) in rainfall in this area would markedly reduce livestock carrying capacity and/or put the resource base at considerable risk from degradation.

The rangelands incorporate a great diversity of plant and animal species. Climate change and rising CO_2 levels have the potential to significantly alter the interactions between plant species in these environments, particularly where there is a delicate balance between the woody and grass layers.

Forestry

Future forest productivity will depend in part on the balance between the benefits of increased CO_2 and the patterns of change in rainfall and temperature.

A doubling of CO_2 with a warming of 3ºC and no rainfall change, possible by 2070, would encourage tree growth across much of southern Australia, particularly in the wheat belt and semi-arid regions. The increases are likely to be more evident (25-50%) in southern Australia near the more marginal wheat growing areas and the fringes of the pastoral zone. However, a reduction in rainfall in winter and spring in southern Australia, and increased fire frequency, would offset some of these benefits. In cases where extreme rainfall changes are projected, such as in south-west Australia, the impacts could still be negative. The benefits will also be affected by changes in pests and in the longer term by limited nutrient supply. Where soil nutrients are limited, there would be little or no benefit from atmospheric CO_2 fertilisation.

More modest increases (0-25%) in tree growth are likely to occur in parts of the semi-arid tropics. However, in the monsoon tropics of far north Queensland and the top end of the Northern Territory, the adverse effect of warming on tree growth will more than offset the gains from a doubling of CO_2, leading to declines of 25-50% in tree growth.

Pests and weeds

Projected warming will increase the ability of pests to survive winters and accelerate the development of most of the species that are active in summer.

Changed climate would enable tropical species, such as Queensland fruit fly and the cattle tick, to spread southwards and threaten exclusion zones established to protect interstate and international trade. Fruit fly damage costs $28.5 million per year at present. If the fruit fly expands its range southwards, damage costs would increase by millions of dollars, but more importantly, the cost of maintaining the exclusion zone is likely to become unprofitable and export markets could be lost. Other temperate pests, such as the light brown apple moth, which causes fruit damage costing $21 million per year, would be displaced from the warmer parts of its current range. Therefore, crops such as oranges and grapes (grown in the warmer areas) will benefit while cooler regions with apples, grapes and pears will face an increased risk of moth damage.

Plant pathogens are likely to become more severe in areas with dry summers if the frequency of summer rainfall events increases. This would affect the viticulture industry in particular, which is vulnerable to botrytis with summer rainfall. Higher CO_2 levels may increase the density of crop foliage and increase the production of pathogens.

Some sub-tropical weeds would benefit directly from climate change and indirectly from reduced competition as unfavourable conditions weaken native species.

Settlements and the built environment

Severe weather affects urban communities in many ways. Torrential rainfall over cities and towns and surrounding catchments can produce severe run-off and flooding. Buildings are damaged not only by the depth of floodwaters, but also by the force of the water flow. Both can contribute to structural fatigue and

collapse. Gales and strong winds directly damage buildings and also generate waves and storm surges that can contribute to coastal flooding.

Each year, severe weather events cause significant damage to the built environment. More than 80% of Australia's population resides within 50 km of the coast. With further growth anticipated, the community's risk from extreme events – notably tropical cyclones, storm surges and flooding of rivers in deltas and other outflow regions – is increasing. Increases in population in risk-prone areas, combined with increases in storm intensities and rising sea levels, mean that the risks to life and property and cost of flood damage to the built environment and infrastructure will increase.

Rising sea level, stronger tropical cyclones and increased intensity of oceanic storm surges are likely with climate change. A study has shown that tropical cyclone intensity around Cairns in northern Queensland could increase by 20% by about 2050. Stronger cyclones would increase the flood level associated with a 1-in-100 year flood in Cairns from the present height of 2.3m to 2.6m; a rise in sea level of 0.1 to 0.4m would result in the flood level increasing further to 2.7 to 3.0m. This would result in flooding occurring over an area about twice that historically affected.

Changes in the timing and amounts of peak seasonal energy loads are likely. Warmer conditions mean less energy demand for winter heating and more energy demand for summer cooling.

Insurance and finance industries are re-evaluating risks associated with insurance in light of changing climate and projections. Expectations of increased coastal property damage due to rises in sea levels, increased storm surge activity and, in the north of Australia, a possible increase in cyclone intensities have major implications for the insurance industry. Other causes of projected large rises in insurance claims as a result of climate change include increased property damage in bushfires and greater flood damage and crop losses resulting from increases in the intensity and frequency of extreme rainfall events. Possible responses by insurance companies to an increase in the frequency of such events include raising premiums, restricting coverage and withdrawing from areas of insurance with the highest risks. The decisions made could have significant economic and social ramifications.

The potential damage to Australia's tourist industry due to climate change could also have substantial economic implications. Statistics for 1999/2000 show that tourism exports totalled $13.1 billion, equivalent to 2.1% of Australia's gross domestic product. Major attractions include the country's unique flora and fauna, vast stretches of coastal beaches, the Great Barrier Reef and the snowfields. Potential direct causes of losses to the industry include damage to beaches and coastal resorts due to rising sea levels and increased storm surge activity, reductions in the extent and duration of snow cover in the Australian Alps and an increased risk of contracting serious insect-borne diseases. Any substantial damage to Australia's biodiversity could also reduce the country's attractiveness to tourists.

Australia may also be affected by the economic impacts of global warming in other parts of the world reflected in changes in other countries' production patterns. In particular, climate change may lead to increased food production in some regions and reductions elsewhere. Some studies show that, overall, global food production could increase in the short term and then decrease as climate change proceeds in the next century. Such an outcome would have flow-on effects to world agricultural trade and could affect agricultural commodities economically important to Australia, such as wheat. Assessment of the impacts of global warming on Australian industries needs to include a global perspective on these industries.

Human health

Climate variability and climate change can harm human health both directly and indirectly. Direct effects include injury and death from heat waves, tropical cyclones and floods. Indirect effects include infectious diseases such as dengue fever, food poisoning from fish contaminated by toxic algal blooms and water-borne diseases such as giardia.

With climate change, parts of Australia may become more favourable for mosquitoes. The potential for mosquito-borne disease infection is likely to increase because warmer conditions would extend the range and growth season of mosquitoes and encourage humans to spend more time outdoors. Higher temperatures would also accelerate the development of viruses and other pathogens in mosquitoes, increasing the efficiency of disease transmission. Adaptation strategies, such as behavioural changes, more screening and ventilation of houses and use of safer repellents, would constrain the effects on human health.

Estimates of the weather-related deaths in Australia between 1803 and 1992 suggest that 40% were due to heatwaves, 20% to tropical cyclones and 20% to floods. An increase in the intensity of these events is anticipated due to climate change. An assessment of climate-related deaths (excluding floods and cyclones) in Australia's five largest cities by the year 2030 indicates that climate change would lead to an increase in climate-related deaths in summer but a decrease in such deaths in winter.

ADAPTATION MEASURES

Adaptation measures are an important strategy in reducing the adverse impacts of climate change and enhancing beneficial effects. All levels of government are placing greater priority on adaptation through development of a coordinated program of activity.

Findings from climate change impacts research form the basis of the development of Australia's adaptation strategies. However, significant challenges exist in developing these adaptation strategies due to uncertainties in climate change science and in projections of possible future climate change at a regional or national level. Other barriers to the development of adaptation strategies include difficulties in ascertaining necessary timeframes for adaptation and institutional barriers to adaptation.

Adaptation Strategies under the National Greenhouse Strategy

The likelihood that some climate change impacts will occur and that policies must respond is recognised in Australia's National Greenhouse Strategy (NGS) which provides the strategic framework for advancing Australia's domestic greenhouse response. One of the three goals of the NGS is to lay the foundations for adaptation to climate change. Module 8 of the NGS outlines various measures concerned with laying the foundation for adaptation to climate change, including the identification, evaluation and removal of barriers to adaptation, improved research to assist in developmental work and assessment of the adaptation requirements of several key sectors.

The adaptation module under the NGS outlines specific action within a national framework for adaptation to climate change and adaptation strategies for key sectors. Work on adaptation strategies has, to date, focused on strengthening the science on which predictions of impacts will be based and on gathering data and perspectives to help shape future policy responses.

The Australian Greenhouse Office is coordinating work in conjunction with Commonwealth agencies and the State and Territory governments to enhance the knowledge base, develop policy advice, increase community awareness and improve access to information.

Australia is committed to continuing studies on the impacts of and adaptation to climate change on natural and human systems. Adaptation studies are under way in some of the key sectors of Australia's economy, such as wheat and grazing, road transport infrastructure and coral bleaching. Other studies are planned for health, the Great Barrier Reef, biodiversity, water supply, and urban planning. CSIRO, for example, has completed a study into adaptation strategies for cropping. These included adjusting planting time and the choice of crop variety.

States and Territories have also developed adaptation strategies. The Victorian Government has initiated a climate change impacts and adaptation program for Victoria. The program is informing and engaging stakeholders with briefings and workshops in key sectors as part of a process to identify and develop projects in key sectors. These will include mapping the effects of climate change in land suitability for agricultural commodities, modelling impacts of climate change on Victoria's flora communities and studies on hydrology, coastal vulnerability, and the Alpine region. CSIRO, with funding from the NSW Government, completed a study on the risk of heat stress to dairy cattle in the NSW Hunter Valley. This study found that milk losses could be minimised under warmer conditions if farmers adapt by providing shade and sprinklers for their herd.

The Queensland Government has completed a study on transport infrastructure in that State and is currently studying coastal storm surge and flooding.

There is increasing focus on integrated assessments to include flow-on effects with some economic and cross sector analyses. Pilot studies are being developed for some regions that are considered to be vulnerable or have vulnerable sectors. The studies use risk assessment to develop guidelines in planning for climate change.

Many of the decision-makers who will be planning for climate change and implementing adaptation strategies are regionally based, such as State and local governments. It is important that they have access to information, guidelines and policy advice. Improved access is planned through briefings, written material, web-based information with search capability and through networking.

CHAPTER SEVEN

FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

The Australian Government, through its overseas aid program, provides assistance for activities in developing countries in support of the United Nations Framework Convention on Climate Change (UNFCCC), particularly in the Asia-Pacific region. The purpose of Australia's overseas aid program, managed by the Australian Agency for International Development (AusAID), is to assist developing countries to reduce poverty and achieve sustainable development. Addressing local and global environmental degradation that impacts disproportionately on developing countries and the poor is an inseparable part of this objective. A number of other Commonwealth and State government agencies also provide significant assistance to developing countries to address climate change issues through the transfer of environmentally sound technology and capacity building.

PROVISION OF FINANCIAL RESOURCES

In accordance with its commitments under Articles 4.3, 4.4 and 4.5 of the UNFCCC, Australia has provided significant financial resources to help developing countries respond to climate change. These resources have been delivered through bilateral, regional and multilateral channels.

Since 1996/1997, Australia has provided over $160 million for bilateral and regional overseas aid activities that contribute to sustainable development while reducing net greenhouse gas emissions, or that help developing countries to adapt to climate change. These resources have been aimed at transferring 'soft' technologies through support for capacity building, information networks, training and research, as well as hardware. Australia has also continued to make financial contributions to multilateral institutions and programs with significant climate change programs, including the Global Environment Facility (GEF).

Details of Australia's multilateral, bilateral and regional assistance are set out below.

Contributions to the Global Environment Facility

Since 1991, Australia has committed over $116 million to the GEF, equivalent to almost 1.5% of total contributions to the GEF. According to official GEF statistics, approximately 40% of funds contributed have been allocated to the GEF's climate change focal area. Between the financial years 1996/1997 and 2000/2001, Australia contributed approximately $30 million to the GEF. Australia's annual contributions during this period are set out in Table 7.1.

Through its GEF contributions, Australia indirectly supports a number of projects complementary to its own bilateral and regional climate change assistance. An example of a GEF-funded climate change project is the Pacific Islands Climate Change Assistance Program (PICCAP), managed through the United Nations Development Program (UNDP) and the South Pacific Regional Environment Program. PICCAP has assisted ten Pacific island countries to meet their reporting obligations to the UNFCCC and develop national implementation plans for climate change. A further example is the Capacity Building for the Rapid Commercialisation of Renewable Energy Project in China, which Australia is co-financing with the GEF and other donors (see text box below).

Other multilateral assistance

In addition to its support to the GEF, Australia funds several other multilateral institutions and programs that contribute to the implementation of the UNFCCC. With support from Australia and other donors, organisations such as the World Bank, the Asian Development Bank and the UNDP have increased their emphasis on climate change issues. Details of Australia's financial contributions to multilateral institutions and multilateral scientific, technological and training programs are set out on an annual basis in Table 7.2.

WORLD BANK'S NATIONAL STRATEGY STUDIES PROGRAM

In 1997, the World Bank launched the National Strategy Studies (NSS) Program, designed to enhance understanding of the Clean Development Mechanism (CDM) under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol) in host countries and to build their capacity to participate in the CDM. Australia has contributed over US$2.9 million to the program. So far this funding has been used to assist governments in Indonesia, Papua New Guinea (PNG), Sri Lanka, Thailand, Vietnam, and Vanuatu. Australia is currently considering, or preparing to support, studies in four other countries in Asia and the Pacific, including India.

The Indonesia and PNG NSS, and preparations for other Studies in the Pacific, have included a focus on the potential for these countries to benefit from the sustainable management of their forests as carbon sinks. This complements Australia's considerable bilateral and regional assistance for sustainable forest management in Indonesia and the South Pacific.

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

In accordance with its obligations, Australia has made timely annual contributions to the budget of the UNFCCC. For the financial years 1996/1997 to 2000/2001, Australia's contributions totalled approximately $1.2 million.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Australia has provided funding to the Intergovernmental Panel on Climate Change (IPCC) for a range of activities, including participation by developing countries at IPCC meetings, workshops and capacity building activities. For the financial years 1996/1997 to 2000/2001, this assistance totalled approximately $500,000.

Australia has also provided substantial financial assistance for lead authors and review editors of IPCC technical and assessment reports.

Bilateral and regional assistance

Australian bilateral and regional overseas aid projects primarily in forestry, land management and renewable energy are helping to reduce greenhouse gas emissions and preserve carbon sinks. In addition, Australia has funded a significant program of assistance to help vulnerable Pacific Small Island Developing States monitor and adapt to climate change. Details of Australia's funding for bilateral and regional activities are set out in Table 7.3.

IN THE PACIFIC

Australia's assistance for greenhouse gas mitigation in the South Pacific has focused on sustainable forestry and renewable energy activities. Significant current and recently completed activities include:

- The PNG Forestry Human Resource Development Project (Australian contribution of $21.3 million), which improved in-country forestry training at the Timber Industry Training College and the University of Technology, strengthened human resource development for all forestry agencies, including NGOs and conservation agencies, and assisted the PNG Forest Authority to enhance its capacity to monitor and control logging.
- The Solomon Islands Forestry Management Project (Australian contribution of $6 million), which aims to implement the *Solomon Islands Forestry Act 1999*, drafted with assistance from Australia. The project will re-establish the monitoring capacity of the Forestry Division's Forest & Revenue Monitoring Unit and seek to increase forestry revenue for forest owners and the Solomon Islands Government.
- The Vanuatu Sustainable Forest Utilisation Project (Australian contribution of $5.5 million), which assisted the Vanuatu Forestry Department in the areas of professional forest management planning, minimum impact logging operations, maximising returns to resource owners and government, and optimising local participation in harvesting and processing. The project developed a Code of Logging Practice and associated legislation and met Vanuatu's expressed need for capacity building.
- The Regional Pacific Renewable Energy Program, jointly funded with the Government of France (Australian contribution of $1.6 million) and implemented by the Secretariat to the Pacific Community. The program is focusing on small-scale renewable energy technologies appropriate for Pacific islands.

IN ASIA

Australia's climate change-related aid activities in Asia have focused on sustainable energy, cleaner production and environmental regulation, land rehabilitation and community reforestation. Several of these activities are discussed under the section in this chapter on technology transfer. Other significant current and recently completed land rehabilitation and reforestation activities include:

- The Karst Environment Rehabilitation Project (Australian contribution of $10.4 million from 2001 to 2005), which aims to address the inter-related problems of environmental degradation, poverty and demand for firewood in degraded Karst mountain areas in Guangxi Zhuang Autonomous Region, southern China. This will involve closing off degraded areas for natural revegetation and the provision of integrated assistance to farming households in agro-forestry, income generating activities and sustainable energy development.
- In Pakistan, the Community Development Project for the Rehabilitation of Saline and Waterlogged Land (Australian contribution of $4.2 million from 1998 to 2003), co-financed with the UNDP. The goal of the project is to increase the income of poor rural farming communities in the Punjab Province through the rehabilitation of saline-affected and waterlogged lands into productive farmland.

- The Qinghai Forestry Resource Management Project (Australian contribution of approximately $10 million over five years, starting in 2001), which aims to support sustainable land and natural resource management through afforestation and improved farming practices along the origin of the Yellow River in Qinghai Province, China.

ASSISTANCE TO DEVELOPING COUNTRIES THAT ARE PARTICULARLY VULNERABLE TO CLIMATE CHANGE

In accordance with Article 4.4, Australia is assisting developing countries in the Asia-Pacific region in their efforts to adapt to climate change. The UNFCCC recognises that Small Island Developing States (SIDS) may be particularly vulnerable and require special assistance. The focus of Australia's assistance to developing countries for climate change adaptation has therefore been on SIDS in the South Pacific. Australia has also contributed $2.6 million for the establishment of a regional Global Change and Terrestrial Ecosystems Centre to help predict the effects of climate change on South-East Asia.

Adaptation assistance to vulnerable South Pacific SIDS

Pacific SIDS have long been concerned about the potential impacts of rising sea levels and increased variability in weather patterns resulting from global climate change. Australia has responded by supporting their efforts to better understand and address their vulnerability through activities focused on long-term sea-level data collection, climate monitoring, vulnerability studies, institutional strengthening, capacity building and technology transfer.

Australia is the largest financial supporter of the Samoa-based South Pacific Regional Environment Program (SPREP). SPREP is instrumental in bringing a strategic and coherent approach to climate issues in the region. A focus of its work on climate change is the South Pacific Sea Level and Climate Monitoring Project, which Australia began funding in 1989 after Pacific nations first voiced their mounting concern about the threat of rising sea levels (refer to Table 7.4).

Other related activities supported through Australia's aid program include the 2000 Linking Science and Policy Pacific island conference on climate change, climate variability and sea level rise, and a 1999 needs analysis for national meteorological services in the Pacific.

Australia's assistance for long-term data collection and analysis is complemented by its support for disaster management in the Pacific. Australian funding helped to establish the South Pacific Disaster Reduction Program, under which Pacific Islanders built their capacity for disaster management and regional disaster coordination. Since 2000, Australia has focused its support for disaster management through the South Pacific Applied Geoscience Commission.

ACTIVITIES RELATED TO TRANSFER OF TECHNOLOGY

Australia's overseas aid program helps partner countries to build capacity, develop enabling environments and to gain access to innovative and environmentally sound sustainable energy and pollution control technologies.

Transfer of environmentally-sound technology

RENEWABLE ENERGY TECHNOLOGY

Australia has gained considerable experience from delivering electricity to remote rural communities using renewable energy technologies. This experience can be adapted to the needs of Australia's Asian and Pacific neighbors where there is significant demand for decentralised rural electrification schemes, especially on small

islands in Indonesia, the Philippines and the Pacific. Recent or current examples of Australian assistance for the transfer of renewable energy technologies include:

- The Renewable Energy Eastern Islands Project in Indonesia, to which Australia is contributing $2.5 million. The project is providing villages in Sulawesi with reliable, low-cost electricity generated by low-maintenance, localised, hybrid renewable energy power stations, thereby reducing household reliance on expensive and polluting oil and kerosene.
- In the Philippines, Australia contributed $13.2 million for the installation of one thousand photovoltaic generators in remote areas of the Philippines to reduce the dependence of communities on non-renewable energy sources such as oil, and demand for fuelwood.

Australia is also helping to promote the use of renewable energy in industrial applications. Under the third phase of the Association of South-East Asian Nations (ASEAN)–Australia Economic Cooperation Program, Australia contributed $4 million to the Energy from Biomass Project which assisted ASEAN countries in the commercial development of fluidised bed combustion technologies for the production of combined heat and power utilising biomass residues.

UNDP/GEF RENEWABLE ENERGY PROJECT – CHINA

Australia is contributing $4.5 million over five years (1998 to 2003) to addressing technical and market barriers to renewable energy technologies in China as part of the UNDP/GEF Capacity Building for the Rapid Commercialisation of Renewable Energy Project. This US$25.8 million project, co-financed by China, Australia and the Netherlands, aims to assist China to shift from supply driven renewable energy technology and market development to demand driven mechanisms that can provide greater opportunities for rapid commercialisation.

The project will develop market-based institutions and instruments, including a Chinese Renewable Energy Industries Association and an Investment Opportunity Facility, to attract new players to the renewable energy industry and increase investments in renewable energy technologies. It will also support pilot activities for five promising technologies (rural solar and wind hybrids, wind farms, biogas, bagasse and solar water heaters) to demonstrate the role of a particular instrument/institution in increasing renewable energy market penetration. A series of capacity building workshops and training activities, involving national government agencies, their provincial affiliates and research institutes, will complement the demonstration activities.

The project builds on the findings of a 1996 World Bank report that many renewable energy technologies are almost ready to compete in the open market with traditional energy sources. The study found that with moderate action in 'levelling the playing field' and promoting renewable energy alternatives, the Chinese economy could draw as much as 6% of its energy supplies and 8% of its power supplies from such sources.

POLLUTION CONTROL TECHNOLOGY

In Indonesia, Australia provided $21 million to the Bapedal East Java Pollution Control Implementation Project. One of the technologies demonstrated is solar-powered, reverse osmosis water purification equipment. This innovative technology not only benefits the global climate, it also assists sustainable development by assuring a clean water supply to local villages.

INTERNATIONAL GREENHOUSE PARTNERSHIPS

As part of the Prime Minister's Safeguarding the Future package in 1997, $6 million were allocated to progress Australian interests in international collaborative projects to reduce greenhouse emissions through the International Greenhouse Partnerships (IGP) Program, which was administered by the IGP Office within the Department of Industry, Tourism and Resources.

Under the Kyoto Protocol, there is provision to undertake greenhouse gas mitigation projects between Annex 1 countries – via Joint Implementation (JI) – and between Annex 1 and non-Annex 1 countries – via the CDM. The IGP Program has aimed to help facilitate the establishment of the CDM and JI under the Kyoto Protocol. The IGP Office has pursued this objective by:

- contributing to the development of international agreement on JI and CDM rules, guidelines and modalities; and
- facilitating the establishment of mutually beneficial emission abatement projects with cooperating Annex I and non-Annex I countries.

A range of cooperative greenhouse projects has been established in several countries, via the Activities Implemented Jointly (AIJ) pilot phase, to gain experience. To date, fifteen pilot projects have been established in nine countries – Chile, Fiji, India, Indonesia, Malaysia, Mauritius, Peru, Solomon Islands and Vietnam – encompassing a range of project types, including solar, micro-hydro, wind, landfill gas recovery, carbon sequestration, energy efficiency, fugitive gas capture, fuel substitution and rural electrification. Recent or current examples of these pilot projects include:

- The International Centre for Application of Solar Energy (CASE) is undertaking a project to use livestock waste to deliver sustainable biogas energy in villages in Vietnam. CASE will be installing up to 100 biogas digesters in outer suburban villages in Hanoi to replace the charcoal used by villagers for day-to-day cooking and heating. Introducing renewable energy through the bio-digesters will be a first step for the villagers to shift their energy production away from current unsustainable practices towards new methods, while reducing the level of methane (CH4) released into the atmosphere.
- Appropriate Technology for Community & Environment Inc (APACE) has undertaken the construction of two micro-hydroelectric, remote area power schemes in rural villages in the Solomon Islands. The schemes will include two mini-grid distribution and reticulation systems. The aim of the project is to reduce the potential greenhouse gas emissions from electricity production in rural Solomon Island villages, and to train local communities in the use of renewable energy technologies.

Capacity building

Australia recognises the importance of capacity building to address climate change, working through both the public and private sectors, and focusing on market-based approaches.

The IGP Office held three workshops and training courses between 1999 and 2001 to increase the capacity of non-Annex 1 countries and Australian industry to participate in the CDM. Representatives from over 20 non-Annex 1 countries have participated in the IGP Office training courses which cover a range of issues, including greenhouse gas reduction opportunities, baseline definitions, emission monitoring and verification, and greenhouse gas reduction estimation methodologies. The workshops and training courses delivered through the IGP Office have complemented the capacity building activities supported through AusAID and the World Bank's NSS Program.

Australia has also contributed $5.4 million to the Energy Policy and Systems Analysis Project, funded through AusAID's ASEAN–Australia Economic Cooperation Program. The project aims to enhance the capacity of ASEAN policy makers and planners to assess the impact of a range of policy options and strategies to tackle economic, technical and environmental problems associated with energy sector activities.

Other Commonwealth and State initiatives

INTERNATIONAL CENTRE FOR APPLICATION OF SOLAR ENERGY

CASE was established in Perth in 1994 with support from both the Commonwealth and Western Australian governments under the auspices of the UNDP. Its functions are to encourage the development of the solar energy industry in Australia and to assist developing countries in matters relating to the application of solar energy technology.

CASE has completed the supply, installation and commissioning of a number of renewable energy projects in developing countries, including Malaysia, Indonesia, Vietnam and Thailand. CASE has also been responsible for organising and coordinating a number of national and international workshops for delegates in Australia and overseas. Additionally, a number of national and international consultancies have been awarded based on CASE's expertise in renewable energy.

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 collaboration helps solve major agricultural and resource problems and strengthen local research capacity.

ACIAR-supported research relevant to climate change includes carbon capture in biomass through development of fast-growing tree species, and reforestation strategies for developing country partners including China, Vietnam and the Philippines. This includes propagation and management strategies for use of Australian and native tree species as well as mangroves. Related collaborative work has aimed to quantify the socio-economic value of forest preservation and biodiversity.

At the farm level, ACIAR aims to minimise greenhouse gas production through demonstrating the value of conservation of crop residues and build-up of soil organic matter and improving production efficiency by reduction of inputs such as energy-intensive nitrogen fertilisers and tillage. ACIAR has also implemented a seasonal climate forecasting (drought and flood early warning) project in India, Indonesia and Zimbabwe that should be sensitive to longer-term climatic change.

CAPACITY BUILDING FOR CLIMATE CHANGE RESEARCH

Australia continues to provide significant technical advice and assistance to neighboring countries in the Asia-Pacific region to support the improvement of climate data management and monitoring capabilities. Further detail of this assistance is set out in *Chapter 8 – Research and Systematic Observation*.

Table 7.1 Financial contributions to the Global Environment Facility

	Contribution (US dollars)				
	1996/1997	1997/1998	1998/1999	1999/2000	2000/2001
Global Environment Facility[1]	$2,869,459	$5,944,222	$2,994,915	$3,424,666	$5,156,485

1. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.2 Financial contributions to multilateral institutions and programs

Institution or Program	Contribution (US Dollars)				
	1996/1997	1997/1998	1998/1999	1999/2000	2000/2001
1. World Bank Group					
• International Bank for Reconstruction and Development (IBRD)[1]	$869,065	$2,871,498	$3,453,183	$3,170,448	–
• International Development Association (IDA)	$100,027,941	$83,738,863	$73,120,818	$74,907,095	$61,599,337
• International Finance Corporation (IFC) Capital Subscription[1]	$4,356,185	$4,599,251	$5,619,216	$5,314,559	–
• Multilateral Investment Guarantee Agency (MIGA) Membership and Subscription[1]	–	–	$1,941,676	–	$1,667,693
• Highly Indebted Poor Country Initiative (HIPC) Trust Fund	–	–	–	$2,200,000	$2,220,000
• National Strategy Studies Program	–	–	$2,000,000	$284,212	$648,223
2. International Monetary Fund (IMF)					
• Poverty Reduction and Growth Facility (PRGF)[1]	$1,668,290	$1,668,290	$1,668,290	$1,668,290	$1,668,290
• PRGF HIPC Trust Fund	–	–	–	$5,575,904	$5,000,135
3. Asian Development Bank					
• Capital Subscription[1]	$1,447,998	$1,617,828	$1,792,953	$1,724,778	$5,038,222
• Asian Development Fund	$59,337,415	$77,125,567	$69,251,468	$69,265,112	$67,696,640
4. European Bank for Reconstruction and Development (EBRD) Membership and Capital[1]	$1,024,690	–	–	–	$8,531,257
5. United Nations Development Program (UNDP)	$7,090,000	$4,350,000	$4,150,000	$4,430,000	$4,000,000
6. United Nations Environment Program (UNEP)	$792,744	$311,400	$320,500	$299,400	$309,300
7. International Fund for Agricultural Development (IFAD)	$1,229,298	$1,111,050	$944,100	$978,000	$758,700
8. United Nations Framework Convention on Climate Change (UNFCCC)	$92,584	$164,255	$102,160	$160,862	$163,537
9. Other					
• Intergovernmental Panel on Climate Change (IPCC)	$79,670	$65,900	$62,990	$63,620	$52,856
• South Pacific Regional Environment Program (SPREP)[1]	$803,849	$800,770	$800,779	$730,008	$734,048
• South Pacific Applied Geoscience Commission (SOPAC)[1]	$531,927	$560,546	$533,853	$533,853	$533,853

1. Current prices, based on an average annual exchange rate of AUD 1 = USD 0.667 (source: OECD Development Assistance Committee statistics for the years 1996-2000). All other figures in the table are current prices reflecting the actual US dollar amount paid in that financial year.

Table 7.3 Bilateral and regional financial contributions related to the implementation of the UNFCCC. Contributions for the financial year 1996/1997 (US dollars).[1, 2]

	Mitigation						Adaptation			Total
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity-building**	**Coastal zone management**	**Other vulnerability assessments**	
PACIFIC										
Papua New Guinea	$133,463	$0	$4,437,704	$0	$0	$0	$0	$0	$0	$4,571,167
Regional – South Pacific	$50,993	$0	$200,195	$0	$0	$0	$75,872	$0	$792,026	$1,119,086
Vanuatu	$0	$0	$1,285,937	$0	$0	$0	$0	$0	$0	$1,285,937
Sub-total Pacific	*$184,456*	*$0*	*$5,923,836*	*$0*	*$0*	*$0*	*$75,872*	*$0*	*$792,026*	*$6,976,191*
ASIA										
China	$3,053,815	$0	$33,364	$0	$0	$0	$0	$0	$0	$3,087,180
India	$0	$0	$0	$0	$0	$15,301	$0	$0	$0	$15,301
Indonesia	$8,500,397	$0	$0	$0	$0	$1,833,458	$0	$0	$0	$10,333,855
Laos	$23,166	$0	$0	$0	$0	$0	$0	$0	$0	$23,166
Maldives	$0	$0	$0	$0	$0	$0	$0	$0	$40,592	$40,592
Nepal	$0	$0	$708,242	$0	$0	$0	$0	$0	$0	$708,242
Pakistan	$0	$0	$47,353	$0	$0	$0	$0	$0	$0	$47,353
Philippines	$8,599,682	$0	$0	$0	$0	$0	$0	$0	$0	$8,599,682
Regional – South East Asia	$516,971	$734,048	$0	$0	$0	$0	$0	$0	$512,150	$1,763,169
Sri Lanka	$0	$0	$1,379,197	$0	$0	$0	$0	$0	$0	$1,379,197
Thailand	$370,197	$0	$0	$0	$0	$0	$0	$0	$0	$370,197
Vietnam	$0	$0	$170,663	$0	$0	$0	$0	$0	$0	$170,663
Sub-total Asia	*$21,064,228*	*$734,048*	*$2,338,820*	*$0*	*$0*	*$1,848,759*	*$0*	*$0*	*$552,743*	*$26,538,598*
AFRICA										
Namibia	$0	$0	$300,292	$0	$0	$0	$0	$0	$0	$300,292
Regional – Southern Africa	$0	$0	$121,180	$0	$0	$0	$0	$0	$0	$121,180
Southern Africa NGO	$0	$0	$129,292	$0	$0	$0	$0	$0	$0	$129,292
Sub-total Africa	*$0*	*$0*	*$550,765*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$550,765*
OTHER										
World – Unspecified	$0	$0	$44,710	$0	$0	$0	$0	$0	$0	$44,710
Sub-total Other	*$0*	*$0*	*$44,710*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$44,710*
Total	**$21,248,684**	**$734,048**	**$8,858,131**	**$0**	**$0**	**$1,848,759**	**$75,872**	**$0**	**$1,344,769**	**$34,110,263**

1. The Australian financial year is from 1 July to 30 June.
2. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.3 (continued) Bilateral and regional financial contributions related to the implementation of the UNFCCC. Contributions for the financial year 1997/1998 (US dollars).[1, 2]

	Mitigation						Adaptation			Total
Recipient country/region	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Capacity-building	Coastal zone management	Other vulnerability assessments	
PACIFIC										
Papua New Guinea	$0	$0	$3,551,743	$0	$0	$0	$0	$0	$0	$3,551,743
Regional – South Pacific	$33,366	$0	$133,463	$0	$0	$0	$54,207	$0	$934,162	$1,155,199
Vanuatu	$0	$0	$1,446,395	$0	$0	$0	$0	$0	$0	$1,446,395
Sub-total Pacific	*$33,366*	*$0*	*$5,131,601*	*$0*	*$0*	*$0*	*$54,207*	*$0*	*$934,162*	*$6,153,337*
ASIA										
China	$1,654,664	$41,258	$66,731	$0	$0	$0	$0	$0	$0	$1,762,653
India	$0	$0	$0	$0	$0	$61,852				$61,852
Indonesia	$755,357	$0	$0	$0	$0	$2,894,740	$0	$0	$0	$3,650,097
Laos	$64,784	$0	$0	$0	$0	$0	$0	$0	$0	$64,784
Nepal	$0	$0	$1,164,148	$0	$0	$0	$0	$0	$0	$1,164,148
Pakistan	$0	$0	$621,526	$0	$0	$0	$0	$0	$0	$621,526
Philippines	$117,454	$0	$0	$0	$0	$0	$0	$0	$0	$117,454
Regional – South East Asia	$679,681	$0	$0	$0	$0	$0	$0	$0	$0	$679,681
Sri Lanka	$0	$0	$1,206,956	$0	$0	$0	$0	$0	$0	$1,206,956
Vietnam	$0	$0	$57,831	$0	$0	$0	$0	$0	$0	$57,831
Sub-total Asia	*$3,271,940*	*$41,258*	*$3,059,362*	*$0*	*$0*	*$2,956,592*	*$0*	*$0*	*$0*	*$9,329,152*
AFRICA										
Southern Africa	$0	$0	$120,641	$0	$0	$0	$0	$0	$0	$120,641
Namibia	$0	$0	$16,349	$0	$0	$0	$0	$0	$0	$16,349
Sub-total Africa	*$0*	*$0*	*$136,991*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$136,991*
OTHER										
World – Unspecified	$0	$0	$88,753	$0	$0	$0	$0	$0	$0	$88,753
Sub-total Other	*$0*	*$0*	*$88,753*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$88,753*
Total	**$3,305,306**	**$41,258**	**$8,416,707**	**$0**	**$0**	**$2,956,592**	**$54,207**	**$0**	**$934,162**	**$15,708,233**

1. The Australian financial year is from 1 July to 30 June.
2. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.3 (continued) Bilateral and regional financial contributions related to the implementation of the UNFCCC. Contributions for the financial year 1998/1999 (US dollars).[1, 2]

	Mitigation						Adaptation			Total
Recipient country/region	Energy	Transport	Forestry	Agriculture	Waste management	Industry	Capacity-building	Coastal zone management	Other vulnerability assessments	
PACIFIC										
Papua New Guinea	$0	$0	$4,493,757	$0	$0	$0	$0	$0	$0	$4,493,757
Regional – South Pacific	$5,117	$0	$70,681	$0	$0	$0	$800,779	$0	$802,896	$1,679,474
Solomon Islands	$0	$0	$35,650	$0	$0	$0	$0	$0	$0	$35,650
Tonga	$781	$0	$0	$0	$0	$0	$0	$0	$0	$781
Vanuatu	$0	$0	$1,110,192	$0	$0	$0	$0	$0	$0	$1,110,192
Sub-total Pacific	*$5,898*	*$0*	*$5,710,281*	*$0*	*$0*	*$0*	*$800,779*	*$0*	*$894,000*	*$7,410,958*
ASIA										
Burma	$0	$0	$388,538	$0	$0	$0	$0	$0	$0	$388,538
China	$631,304	$0	$111,890	$0	$0	$0	$0	$0	$0	$743,194
India	$0	$0	$16,034	$0	$0	$23,300	$0	$0	$0	$39,334
Indonesia	$0	$0	$0	$0	$0	$3,304,490	$0	$0	$0	$3,304,490
Laos	$21,797	$0	$0	$0	$0	$0	$0	$0	$0	$21,797
Maldives	$0	$0	$0	$0	$0	$0	$0	$24,816	$0	$24,816
Nepal	$0	$0	$2,088,898	$0	$0	$0	$0	$0	$0	$2,088,898
Pakistan	$0	$0	$275,938	$0	$0	$0	$0	$0	$0	$275,938
Philippines	$312,062	$0	$0	$0	$0	$0	$0	$0	$0	$312,062
Regional – South East Asia	$665,148	$0	$0	$0	$0	$0	$0	$0	$91,103	$756,251
Sri Lanka	$0	$0	$77,302	$0	$0	$0	$0	$0	$0	$77,302
Sub-total Asia	*$1,630,311*	*$0*	*$2,958,601*	*$0*	*$0*	*$3,327,790*	*$0*	*$24,816*	*$182,207*	*$8,123,725*
AFRICA										
Namibia	$0	$0	$16,349	$0	$0	$0	$0	$0	$0	$16,349
Southern Africa	$0	$0	$52,123	$0	$0	$0	$0	$0	$0	$52,123
Sub-total Africa	*$0*	*$0*	*$68,472*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$68,472*
Total	**$1,636,209**	**$0**	**$8,737,353**	**$0**	**$0**	**$3,327,790**	**$800,779**	**$24,816**	**$1,076,206**	**$15,603,1543**

1. The Australian financial year is from 1 July to 30 June.
2. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.3 (continued) Bilateral and regional financial contributions related to the implementation of the UNFCCC. Contributions for the financial year 1999/2000 (US dollars).[1, 2]

	Mitigation						Adaptation			Total
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity-building**	**Coastal zone management**	**Other vulnerability assessments**	
PACIFIC										
Papua New Guinea	$0	$0	$2,674,005	$660,192	$0	$0	$0	$0	$0	$3,334,198
Regional – South Pacific	$167,090	$0	$111,311	$0	$0	$0	$796,729	$0	$1,145,017	$2,220,148
Solomon Islands	$0	$0	$849,299	$0	$0	$0	$0	$0	$0	$849,299
Tonga	$175,681	$0	$0	$0	$0	$0	$0	$0	$0	$175,681
Vanuatu	$0	$0	$634,945	$0	$0	$0	$0	$0	$0	$634,945
Sub-total Pacific	*$342,772*	*$0*	*$4,269,560*	*$660,192*	*$0*	*$0*	*$796,729*	*$0*	*$1,145,017*	*$7,214,270*
ASIA										
Burma	$0	$0	$42,020	$0	$0	$0	$0	$0	$0	$42,020
China	$446,865	$0	$852,791	$0	$0	$158,920	$0	$0	$0	$1,458,576
India	$0	$0	$186,986	$0	$0	$0	$0	$0	$0	$186,986
Indonesia	$1,681,637	$0	$0	$0	$0	$243,831	$0	$0	$0	$1,925,468
North Korea	$0	$0	$3,334,277	$0	$0	$0	$0	$0	$0	$3,334,277
Laos	$24,041	$0	$0	$0	$0	$0	$0	$0	$0	$24,041
Maldives	$0	$0	$0	$0	$0	$0	$0	$309,642	$0	$309,642
Mekong Basin Sub-Region	$0	$0	$52,744	$0	$0	$0	$0	$0	$0	$52,744
Nepal	$0	$0	$1,451,853	$0	$0	$0	$0	$0	$0	$1,451,853
Pakistan	$0	$0	$415,516	$0	$0	$0	$0	$0	$0	$415,516
Philippins	$139,415	$0	$0	$0	$0	$0	$0	$0	$0	$139,415
Regional – South East Asia	$1,054,713	$0	$0	$326,865	$0	$0	$0	$0	$0	$1,381,578
Sri Lanka	$0	$0	$213,261	$0	$0	$0	$0	$0	$0	$213,261
Thailand	$29,752	$0	$0	$0	$0	$0	$0	$0	$0	$29,752
Vietnam	$0	$0	$0	$72,668	$0	$0	$0	$0	$0	$72,668
Sub-total Asia	*$3,376,421*	*$0*	*$6,549,449*	*$399,533*	*$0*	*$402,751*	*$0*	*$309,642*	*$0*	*$11,037,796*
AFRICA										
Mozambique	$0	$0	$267,113	$0	$0	$0	$0	$0	$0	$267,113
Southern Africa	$0	$0	$26,325	$0	$0	$0	$0	$0	$0	$26,325
Tanzania	$0	$0	$167,087	$0	$0	$0	$0	$0	$0	$167,087
Zimbabwe	$0	$0	$0	$125,598	$0	$0	$0	$0	$0	$125,598
Sub-total Africa	*$0*	*$0*	*$460,525*	*$125,598*	*$0*	*$0*	*$0*	*$0*	*$0*	*$586,124*
Total	**$3,719,193**	**$0**	**$11,279,534**	**$1,185,324**	**$0**	**$402,751**	**$796,729**	**$309,642**	**$1,145,017**	**$18,838,190**

1. The Australian financial year is from 1 July to 30 June.
2. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.3 (continued) Bilateral and regional financial contributions related to the implementation of the UNFCCC. Contributions for the financial year 2000/2001 (US dollars).[1, 2]

	Mitigation						Adaptation			Total
Recipient country/region	**Energy**	**Transport**	**Forestry**	**Agriculture**	**Waste management**	**Industry**	**Capacity-building**	**Coastal zone management**	**Other vulnerability assessments**	
PACIFIC										
Papua New Guinea	$0	$0	$3,745,051	$0	$0	$0	$0	$0	$0	$3,745,051
Regional – South Pacific	$333,658	$0	$74,051	$0	$0	$0	$0	$0	$1,146,870	$1,554,579
Solomon Islands	$0	$0	$677,920	$0	$0	$0	$0	$0	$0	$677,920
Tonga	$207,641	$0	$0	$0	$0	$0	$0	$0	$0	$207,641
Vanuatu	$0	$0	$99,766	$0	$0	$0	$0	$0	$0	$99,766
Sub-total Pacific	*$541,299*	*$0*	*$4,596,787*	*$0*	*$0*	*$0*	*$0*	*$0*	*$1,146,870*	*$6,284,957*
ASIA										
Burma	$0	$0	$251,433	$0	$0	$0	$0	$0	$0	$251,433
China	$642,800	$0	$896,494	$625,153	$0	$492,851	$0	$0	$0	$2,657,299
India	$0	$0	$26,693	$0	$0	$0	$0	$0	$0	$26,693
Indonesia	$0	$0	$274,135	$0	$0	$0	$0	$0	$0	$274,135
Laos	$34,128	$0	$0	$0	$0	$0	$0	$0	$0	$34,128
Maldives	$0	$0	$0	$0	$0	$0	$0	$491,883	$0	$491,883
Mekong Basin Sub-Region	$0	$0	$113,528	$0	$0	$0	$0	$0	$0	$113,528
Nepal	$0	$0	$1,538,930	$0	$0	$0	$0	$0	$0	$1,538,930
Pakistan	$0	$0	$686,875	$0	$0	$0	$0	$0	$0	$686,875
Regional – South East Asia	$715,987	$0	$0	$0	$0	$0	$0	$0	$0	$715,987
Sri Lanka	$0	$0	$108,723	$0	$0	$0	$0	$0	$0	$108,723
Thailand	$0	$222,696	$11,345	$0	$0	$0	$0	$0	$0	$234,041
Vietnam	$0	$0	$106,537	$0	$0	$0	$0	$0	$0	$106,537
Sub-total Asia	*$1,392,915*	*$222,696*	*$4,014,693*	*$625,153*	*$0*	*$492,851*	*$0*	*$491,883*	*$0*	*$7,240,191*
AFRICA										
Mozambique	$0	$0	$270,048	$0	$0	$0	$0	$0	$0	$270,048
Tanzania	$0	$0	$263,979	$0	$0	$0	$0	$0	$0	$263,979
Zimbabwe	$0	$0	$126,979	$0	$0	$0	$0	$0	$0	$126,979
Sub-total Africa	*$0*	*$0*	*$661,006*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$661,006*
Total	**$1,934,215**	**$222,696**	**$9,272,487**	**$625,153**	**$0**	**$492,851**	**$0**	**$491,883**	**$1,146,870**	**$14,186,154**

1. The Australian financial year is from 1 July to 30 June.
2. Based on an average annual exchange rate of AUD 1 = USD 0.67 (source: OECD Development Assistance Committee statistics for the years 1996-2000).

Table 7.4 Description of selected projects or programs that promote practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies.

Project / Program Title:
Regional South Pacific-Australia Sea Level and Climate Monitoring Project

Purpose:
To provide an accurate, long-term record of sea levels in the South Pacific for partner countries and the international scientific community.

Recipient country	Sector	Total funding	Years in operation
South Pacific	Other – vulnerability	US$4 million	January 2001 – December 2005

Description:
The project is assembling an archive of sea level and related climate data that Pacific island countries require to manage their near-shore and coastal resources sustainably and to respond to long-term sea level and climate trends. It also aims to develop capacity within national and regional agencies to acquire, manage, and disseminate data and information about sea level variation.

The project builds on the achievements of two earlier Australian-funded project phases, initiated in response to concerns over the potential impact of climate change and sea level rise on Pacific island countries. Phase I (1989-1995) saw the installation of 11 sea level monitoring stations around the Pacific, a transmission network and computer databases to collect, store and analyse data from the stations. Phase II (July 1995-March 2001) emphasised training, public education and the provision of monthly data reports that can be used by partner governments in vulnerability studies, integrated coastal management programs, and contingency planning.

Australia's main contribution to the third project phase will be a team of long and short-term technical specialists to work with national and regional counterpart staff. Australia is also funding communication and telemetry costs, database establishment and maintenance, and the procurement and maintenance of monitoring equipment.

Indicate factors which led to project's success:
The project addresses specific priority concerns identified by Pacific island countries.

Technology transferred:
Sea level and climate monitoring equipment and databases;

National and regional capacity to gather and analyse sea level and climate data.

Impact on greenhouse gas emissions/sinks (optional):
(Not applicable)

Table 7.4 (continued) Description of selected projects or programs that promote practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies.

Project / Program Title: Nepal-Australia Community Resource Management Project			
Purpose: To improve the living standards of rural communities in the Sindhu Palchok and Kabhre Palanchok districts of Nepal's Middle Hills through sustainable community forestry.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
Nepal	Forestry	US$6 million	April 1997 – March 2002
Description: Australia has provided assistance to develop forestry in Nepal since 1962. In Phase 1, from 1962-1978, Australia's principal aim was to provide technical assistance to the Department of Forests to develop fuel wood forests for the Kathmandu Valley and to arrest the erosion of surrounding hills. Phase 2 operated in a policy environment, which resulted in increased attention to community forestry, while Phase 3 (1978-1991) built on the project's pioneering work in community forestry, forging direct links between the community and forest preservation. In the fourth phase (1991-1996), emphasis was placed on Forest User Groups, training, dissemination of information, locally managed nurseries, income generation, and forest resource utilisation. The fifth phase of the project aims to consolidate the achievements of earlier phases by developing local level institutions, and the means of providing support to them. Communities will become more skilled in assessing their own needs and utilising common resources in a sustainable way to fund those needs.			
Indicate factors which led to project's success: The project has had a major impact through training to assist communities to manage their natural resources, especially literacy training for which there is strong demand. Emphasis has been placed on community based management models. **Lessons Learned:** Project ownership by the Nepal Government and local community has been essential to the success of the project. Providing communities with tools for broader community development is essential for longer-term sustainability.			
Technology transferred: Community based natural resource management (forestry/reafforestation).			
Impact on greenhouse gas emissions/sinks (optional): (Not quanitfied)			

Table 7.4 (continued) Description of selected projects or programs that promote practicable steps to facilitate and/or finance the transfer of, or access to, environmentally sound technologies.

Project / Program Title: China-Australia Datong Cleaner Environment Project			
Purpose: To improve the environment and hence the living conditions and health of residents of the Datong municipality and surrounding regions.			
Recipient country	**Sector**	**Total funding**	**Years in operation**
China	Industry	US$3 million	March 2001 – April 2004
Description: The Datong Cleaner Environment Project will demonstrate cleaner production techniques in a polluting coal gasification plant, the Datong Coking Gas Company, to bring it into compliance with Chinese environmental protection legislation. The project is expected to result in significant reductions in fugitive atmospheric emissions from coking ovens, as well as local improvements to water quality, benefiting health and agricultural production. Indirect benefits of the project are potentially even greater as the upgraded plant will serve as a model of improved environmental practice and profitability to some 1 000 other coking plants throughout Shanxi Province.			
Indicate factors which led to project's success: A dual strategy is being pursued to maximise the likelihood of the project achieving its objectives: implementing cleaner production within an individual coal gasification plant so that personnel and equipment at the plant can operate in compliance with government legislation and requirements; and building capacity within the provincial Environment Protection Bureau (EPB) and Water Resource Management Committee (WRMC) so that they can facilitate compliance of coal gasification plants with environmental legislation.			
Technology transferred: Improved policies, strategies and procedures in the EPB and WRMC; improved operating policies, strategies and equipment in the Datong Coking Gas Company, consistent with international best practice; and wastewater treatment technology procured locally.			
Impact on greenhouse gas emissions/sinks (optional): (Not quanitfied)			

CHAPTER EIGHT
RESEARCH AND SYSTEMATIC OBSERVATION

Australian scientists have continued to play an active role in climate, climate change and climate variability research. This commitment to research, combined with Australia's geographic location and size, means that it continues to have the most comprehensive research and monitoring activities related to climate change in the Southern Hemisphere.

Australia supports this commitment through a broad base of greenhouse science research and systematic observation aimed at advancing 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 Intergovernmental Panel on Climate Change (IPCC).

GENERAL POLICY ON RESEARCH AND SYSTEMATIC OBSERVATION

Climate research in Australia is conducted by many organisations and institutions. Key Commonwealth agencies that undertake this research include the Bureau of Meteorology, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Cooperative Research Centre (CRC) for the Antarctic and Southern Ocean Environment. Other government agencies, including the Australian Antarctic Division, as well as several Australian universities, also contribute to Australia's climate research. The Australian Greenhouse Science Program, managed by the Australian Greenhouse Office, provides strategic research funding to Commonwealth agencies such as the Atmospheric Research and Marine Research divisions of CSIRO, the Bureau of Meteorology Research Centre (BMRC), and the National Tidal Facility. The Greenhouse Science Advisory Committee provides strategic advice to the Commonwealth Government on the global status of greenhouse science.

Research and development of strategies to respond and adapt to climate variability and change is carried out or supported by a range of agencies, including CSIRO, the Bureau of Rural Sciences, the Australian Bureau of Agricultural and Resource Economics, the Commonwealth Research and Development Corporations through the Climate Variability in Agriculture Research & Development Program, as well as State and Territory government agencies, such as the Queensland Centre for Climate Applications.

Specific research into the carbon cycle is also carried out with support from the Commonwealth Government. For example, the Cooperative Research Centre (CRC) for Greenhouse Accounting undertakes research with support from the Australian Greenhouse Office to increase understanding of the Australian terrestrial carbon cycle and the forces driving change, predict biophysical responses to global change, develop methods for accurately measuring terrestrial carbon fluxes, sources and sinks, and develop innovative ways to manage the Australian carbon cycle to lower greenhouse gas emissions. The Australian Greenhouse Office's National Carbon Accounting System, initiated in 1998 to address the estimates of emissions and sinks in land-based sectors, also participates in the CRC for Greenhouse Accounting. Through some 33 technical publications, the National Carbon Accounting System has provided collations of relevant information and technical guides that update the current state of knowledge of carbon accounting. Key outputs are the multi-temporal land cover change projects and monthly climate mapping, analyses of land management practice, and soil carbon and biomass modelling of the Australian continent at a 25 m resolution over 30 years, 1970 – 2000.

As the global climate system does not recognise national boundaries, the task of monitoring, understanding and predicting changes in the system, and the consequences of those changes, requires cooperative and coordinated international action. Australian researchers contribute significantly to international climate research through their direct participation in the activities of the World Climate Research Programme (WCRP), the World Climate Impacts and Response Strategies Programme (WCIRP), and other climate-related programs, such as the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP). Coordination with these major international climate and global change programs is carried out by the Australian Academy of Science's National Committee for Climate and Global Change. Australian participation in the IGBP and the WCRP is assisted by the Australian Greenhouse Science Program, which also supports the international project office of the Global Change and Terrestrial Ecosystems project of the IGBP.

Australia has established and maintains national networks of meteorological, atmospheric, oceanographic and terrestrial observing systems, which provide the basis for its climate observing network and contribution to global climate monitoring. These networks contribute to the Global Climate Observing System (GCOS). Established in 1992, GCOS is intended to be an international, long term global observing program, designed specifically to meet the comprehensive requirements for monitoring the climate, providing the observational basis for detecting climate change, for predicting climate variations and change on a variety of time and space scales, and for assessing the impacts of climate change. GCOS builds upon, and works in partnership with, other observing systems such as the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS), and the Global Observing System and the Global Atmosphere Watch (GAW) of the World Meteorological Organization (WMO).

Australia's participation in the GCOS, GOOS and GTOS is planned and coordinated through the Australian GCOS/GOOS/GTOS Joint Working Group which reports to a Steering Committee consisting of Australian representatives of the principle international sponsoring organisations of GCOS, GOOS and GTOS. The GCOS/GOOS Secretariat within the Bureau of Meteorology supports the work of the Joint Working Group.

Australia's meteorological observing network, which contributes to the Global Observing System of the World Weather Watch Programme of the WMO, is operated and maintained by the Bureau of Meteorology. Marine

and ocean observation programs are operated by a number of Australian organisations, including the Bureau of Meteorology, CSIRO Marine Research, the National Tidal Facility, the Royal Australian Navy and the Australian Institute of Marine Science.

RESEARCH

Climate processes

Improved understanding of the key climatic processes that control aspects of climate change is a continuing theme in Australian climate research. The BMRC, CSIRO's Marine Research and Atmospheric Research divisions, the CRC for the Antarctic and Southern Ocean Environment and many universities have active research programs addressing climate processes. These programs contribute to international research efforts under the WCRP, the IGBP and other climate-related programs. Examples of recent activities under these programs include:

- ongoing research on aerosols, with a focus on estimating aerosol radiative properties from satellite data;
- continuing studies of the large-scale controls on rainfall in the Australian region;
- development of a digital atlas of the temperature in the upper ocean of the South-West Pacific for the period 1955-1988, which has been used in a range of studies, including investigations of the interannual variability of the region and of the propagation of large-scale waves across the Pacific;
- analysis of the sub-surface structure of the Antarctic Circumpolar Wave and the role of eddy fluxes in the heat and momentum budgets of the Southern Ocean;
- derivation of a comprehensive description of eddy formation in the East Australia Current;
- investigation, through a major multidisciplinary experiment in the Mertz Glacier Polyna, Antarctica, into the role of polynas in the formation of bottom water and thus ocean circulation;
- significant contributions to the development of a new joint program of IGBP and WCRP called Surface Ocean Lower Atmosphere Study which focuses on the interactions between the atmosphere and marine biogeochemical processes; and
- a broad spectrum of IGBP research, such as new methods for reconstruction of past climates, combining measurement and modeling studies to provide estimates of the net regional sources and sinks of greenhouse gases across Australia, and better understanding of components of climate modeling, including the carbon cycle and aerosols.

Climate modelling

Australia has an active program of climate model development. Climate models are used in a wide range of applications from climate process studies to seasonal prediction and climate change projections.

Australian modelling groups have participated in the major international model intercomparison studies aimed at identifying and reducing the sources of error in global climate models – including the Atmospheric Model Intercomparison Project, the Coupled Model Intercomparison Project and the Project for Intercomparison of Landsurface Parameterisation Schemes.

Much of the uncertainty affecting the capability of climate models to make accurate projections of future climate is associated with the representation of water vapour and clouds in models. Detailed studies by BMRC of the feedback between radiative transfer and water processes in the atmospheric models have quantified the relative importance of specific features, such as the microphysical properties of clouds, in climate simulations.

Ocean measurement projects have provided the foundation for studies by the Marine Research division

of CSIRO to improve ocean models, including improvements in the representation of mesoscale eddies that account for a substantial poleward flux of heat, the representation of the compressibility of ocean water and the representation of the conservation of heat.

The Australian Community Ocean Model has been integrated by CSIRO's Marine Research division over the 20 year period from 1980 to produce a dynamically consistent dataset for investigating the role of the oceans in climate variability. Ocean models have also been used at Macquarie University to investigate the role of Rossby waves in determining the behaviour of the thermocline and western boundary currents, and at the University of New South Wales to identify the role of the westerly winds in the formation of Sub-Antarctic Mode Waters and to clarify the mechanisms controlling the variability of the upper ocean.

Box-model studies have been carried out at Macquarie University to investigate long-term climate change associated with the formation of Antarctic Bottom Water, with a focus on the role of sea ice and polynyas.

A collaborative project between the University of New South Wales and CSIRO's Marine Research and Atmospheric Research divisions has led to an estimation of sea-level rise under climate change conditions that takes account of ocean overturning rates. The project uses a hierarchy of coupled models to improve the estimation of sea-level rise due to thermal expansion. Further studies with the CRC for the Antarctic and Southern Ocean Environment have quantified the impacts of melting from non-polar glaciers and ice caps on sea-level rise over this century. Model experiments by the CRC for Antarctic and Southern Ocean Environment have also investigated the response of Antarctic sea ice to increasing levels of carbon dioxide over the last century.

A joint project between the Atmospheric Research division of CSIRO and the Antarctic Cooperative Research Centre has considered the long-term response of the climate system under different scenarios for the stabilisation of the level of greenhouse gases in the atmosphere.

Both BMRC and CSIRO have developed global coupled ocean-atmosphere models for long-lead (6 – 12 month) climate predictions for the Australian region, focussing on the birth and development of El Niño and La Niña events and the evolution of the Southern Oscillation Index. These developments depended strongly on ocean data now available from networks in the Pacific and Indian Oceans.

There is work in several groups to improve Australia's capability to derive regional and local estimates of weather and climate from large-scale models. This research has shown that downscaling techniques allow different climate models to produce consistent estimates of local climate. Downscaling is relevant not only to climate change projections, but also to the refinement of seasonal predictions from models.

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Climate impacts

Research into the impacts of climate, climate variability and climate change on natural and human systems has increased significantly in Australia in recent years. Most of the recent Australian impact studies have used temperature and rainfall scenarios developed from climate models run by CSIRO, BMRC and international groups. CSIRO's Atmospheric Research division has developed detailed projections of climate change for Australia based on a set of scenarios of future greenhouse gas and aerosol emissions developed by the IPCC. These projections, and a broad assessment of likely impacts, were released in May 2001, and are presented in detail in *Chapter 6 – Vulnerability Assessment, Climate Change Impacts and Adaptation*.

Communicating the outcome of this research is an important component of the Australian Greenhouse Science Program. Activities of this nature are described in *Chapter 9 – Education, Training and Public Awareness*.

AGRICULTURE AND FORESTRY

A range of studies have been undertaken on the impacts of climate variability and change on agriculture and forestry.

The influence of higher CO_2 levels on wheat growth will be particularly pronounced in Australia because Australian wheat is often grown under conditions of limited water. To assess the potential impacts of climate change on Australian wheat production, CSIRO has investigated the effect on wheat yield of doubling CO_2 concentration under a range of temperature and rainfall scenarios. CSIRO is also developing a forecasting system for the agricultural community using a lagged statistical relationship between satellite-derived ocean temperatures and plant growth.

Investigations of climate change and climate variability impacts on agriculture have also been undertaken by State and Territory agencies. The potential changes in animal carrying capacity and heat stress, for example, have been calculated as a function of potential climate change.

The response of plant growth to climate change remains one of the unresolved issues in understanding the future of the terrestrial biosphere. CSIRO has investigated this issue for forest plantations using a comprehensive forest growth model that incorporates fluxes of carbon and water, interception of radiation and nutrient cycling. Researchers parameterised the model for *Pinus radiata*, Australia's most important commercial plantation species.

FISHERIES

CSIRO is assembling time series of fisheries and climate data to study the impacts of climate variability on the growth of fish and on fish stocks. The project, which has funding from the Fisheries Research and Development Corporation, is helping to underpin better fisheries management.

The CSIRO Biosphere Working Group has used a climate model and a biogeochemical model to estimate the decline in oxygen and nutrients in the upper and mid-depth ocean due to a reduction in ventilation rate arising from global warming.

NATURAL ECOSYSTEMS

Native plant species that are rare or restricted in range may be particularly vulnerable to climate change. To begin to assess this vulnerability, Murdoch University has applied the results of a CSIRO climate change model to the growing conditions of the flowering plant *Dyandra*, a native of Western Australia. The Victorian Government is currently funding research on modelling the impacts of climate change on Victoria's flora communities.

The Queensland Department of Natural Resources is modelling natural resource systems using climate change scenarios to examine future primary production. The project entails analysis of historical and current statistical seasonal forecasting and decadal and inter-decadal forcing on natural resource productivity, along with the development of a dynamical, seasonal forecasting approach to account for climatic change.

Coral bleaching, which is a response of corals to environmental stress, may increase in frequency with rising sea-surface temperatures and reduce the ability of corals to recover from such events. The Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority and CSIRO are investigating the observed patterns of temperature change and coral bleaching on the Reef in an attempt to better define the biological thresholds for bleaching. In a related project, the Queensland Department of Natural Resources is combining

projections of future climate on the Reef with biological data on coral stress thresholds to determine whether a greenhouse-induced warming trend will have a discernable effect on the frequency of coral bleaching events and which areas of the Reef are likely to be most vulnerable.

HUMAN HEALTH

Studies to address the potential health impacts of climate change include the work of the National Arbovirus Advisory Committee, on improved modelling of arbovirus out-breaks, such as Australian encephalitis, Ross River virus and the Barmah Forest virus, and the work of the Queensland National Research Centre for Environmental Toxicology, on the potential occurrence and distribution of cyanobacteria and the potential for associated human health problems.

TRANSPORT

In 2000 the Queensland Department of Transport completed a major study on the effects of climate change on transport infrastructure in regional Queensland, including roads, rail, ports and airports. The focus of the project was to identify the impacts that may directly affect these transport systems and develop response strategies.

COASTAL COMMUNITIES

More than 80% of Australia's population resides within 50 km of the coast, with further growth expected. Research into the potential impacts of climate change on these communities, by CSIRO, the Bureau of Meteorology and various State government departments, is addressing the potential changes in the risk of storm surge inundation and the associated cost of flood damage arising from the projected changes in tropical cyclone intensity and sea level rise.

Climate change mitigation

Australian research into options for mitigating climate change is proceeding on a broad front, with investigations into reducing greenhouse gas emissions as well as research into the impacts of various domestic policy options.

The Bureau of Rural Sciences is working on projects that will lead to more accurate estimates of greenhouse gas emissions from the agriculture sector and methods to quantify emission reduction opportunities for agricultural land uses and for the forestry sector.

Australian organisations are also very active in the research and development of renewable energy technology, particularly solar energy. Recent examples include:

- Pacific Solar, a joint venture between Pacific Power, Unisearch and recently Eurosolare, was formed to research and develop thin-film solar photovoltaic cells;
- the Centre for Photovoltaic Engineering is working on photovoltaic technology with efficiency above 30% and on reducing cell costs by depositing the solar cell material directly onto glass;
- the Photovoltaic Research Group from the Australian National University's Centre for Sustainable Energy Systems has been conducting strategic research in the photovoltaic area, including the invention of a high efficiency low cost concentrator solar cell. This Group, in conjunction with the Australian Cooperative Research Centre for Renewable Energy, Western Power Corporation, the Australian Greenhouse Office and Solahart Industries, have been developing a parabolic photovoltaic trough concentrating system for producing electricity and hot water;

- the Bureau of Meteorology's regional scale weather analyses and CSIRO's The Air Pollution Model are being used to model the potential for wind power generation throughout eastern Australia's mountainous regions.

CSIRO's Atmospheric Research division has been investigating the environmental impact of the new Australian hybrid electric cars in terms of greenhouse gas emissions, energy consumption and air pollution exposure in urban areas. The Australian Institute for Tropical Architecture has focussed recent research into energy efficient building for the warm humid tropics. Issues relating to heat transfer of the building fabric, insulation, shading, natural ventilation, as they are applied to building codes, regulations and energy rating systems were investigated.

The Australian Bureau of Agricultural and Resource Economics (ABARE) conducts a major program of research to identify optimal international policies for responding to climate change and appropriate relationships between international and national policy. ABARE has developed and applied a computable general equilibrium model of the global economy (GTEM) to assist policymakers to better understand the effectiveness, efficiency and cost consequences of various greenhouse gas abatement options.

Climate change adaptation

Research into options for adaptation to climate change is developing in Australia within the framework of the National Greenhouse Strategy. Research is being undertaken to integrate our increasing understanding of climatic variability and change with agricultural simulation models to objectively assess agriculture management options. Decisions based on these tools range from short-term, tactical crop management options to policy decisions about future land use.

Other tools are being developed to inform adaptation strategies for urban settlements. For example, CSIRO has developed an integrated modelling system to examine the effect of extreme rainfall events on coastal urban areas. The modelling system couples a high-resolution atmospheric model with a storm surge and inundation model. By integrating these modelling tools with geographic information systems, the modelling results can be applied to a range of subjects, including residential evacuation strategies, assessments of long- and short-term damage to housing and businesses, building design guidelines and material selection, disruption of transport networks and effects on human health.

Details of Australia's adaptation strategies are set out in *Chapter 6*.

SYSTEMATIC OBSERVATION

The plan for an Australian Climate Observing System (ACOS), completed in December 1997, provides the framework for Australia's systematic observation of climate. Australia contributes to the systematic observation of the global climate under GCOS through the provision of meteorological and oceanographic observations and through participation in international terrestrial and space-based observing programs. This work is planned and coordinated through the Australian GCOS/GOOS/GTOS Joint Working Group, supported by the GCOS/GOOS Secretariat within the Bureau of Meteorology.

The ACOS plan sets out the components necessary for a system capable of supplying observational data for the improved understanding of the global and Australian climate, prediction of seasonal and inter-annual variations in Australia's climate and the detection and quantification of longer-term climate change. It catalogues the observing systems that currently exist and recommends enhancements and additions to them, in particular those that could realistically be implemented in the next ten years. The plan covers measurements of the land-surface climate, atmospheric constituents, atmospheric circulation, radiation,

hydrology, surface-air interactions, ocean circulation and climate, sea level and the cryosphere. Paleoclimatic studies, along with the issues of data and network management, are also covered. A summary of the plan is available from the Bureau of Meteorology's website at **http://www.bom.gov.au**.

Progress has also been made on the planning for an Australian Ocean Observing System (AOOS), within the context of Australia's Oceans Policy (1998) and Marine Science and Technology Plan (1999). The plan sees AOOS as including the biological and chemical environments as well as the physical, and sets it in the international context of GOOS and the related GCOS. A set of pilot projects have been nominated as the potential core for the development of an AOOS and these are currently being implemented by various agencies.

A Southern Hemisphere focus for the GOOS has been provided through the establishment in Australia of a Regional Program Office of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). The Office was established in Perth during 1999 under a tripartite arrangement between the IOC, the Bureau of Meteorology and the Western Australian Government. The role of the Perth Office is to facilitate the development and implementation of GOOS activities in the Indian Ocean, South West Pacific and South East Asia, and to build the capacity of countries in the region to participate.

Meteorological and atmospheric observations

Australia maintains observing stations in the GCOS Surface Network (GSN), GCOS Upper Air Network (GUAN) and the Global Atmosphere Watch (GAW). These stations are located on the Australian mainland, on remote islands and in Antarctica. The GSN, GUAN and GAW Regional and Ozone monitoring stations are operated and maintained by the Bureau of Meteorology. The funding and management of the operation of the Cape Grim Baseline Air Pollution Station GAW global observatory in Tasmania is the responsibility of the Bureau of Meteorology, while leadership of the associated research program, which combines the collaborative efforts of a number of Australian and international institutions, is centred on the relevant activities of CSIRO's Atmospheric Research division.

In general, the operation of Australia's GSN, GUAN and GAW stations adheres to the GCOS climate monitoring principles and best practices.

All computerised data for Australian GSN and GUAN stations, and some from the GAW stations, are stored in the Australian Data Archive for Meteorology. Monthly data are available from the late 1800s. Hourly and daily data have generally only been computerised from the late 1950s, although the remainder are available in hardcopy formats. Vast amounts of hardcopy climate records, such as observation field books, rainfall record sheets, pluviographs, upper-air traces and CLIMAT message forms, are held in store by the National Archives of Australia. A current project to digitise the historical hourly and daily climate data from 50 key stations across the country aims to improve the accessibility of these records.

There are currently more than 22 000 paper files holding metadata relating to observation stations within Australia. In recent years the Bureau of Meteorology has developed a relational database to store metadata concerning site location, instrumentation, calibration results, equipment faults and observation program details. A number of current projects are addressing the quality and availability of metadata, including the historical seeding of the national metadata database, the imaging of paper history files to allow access to digital images of site diagrams and photographs, and the collation of historical observation practices.

All Australian GSN, GUAN and GAW station data are routinely provided to the relevant international archive.

Oceanographic observations

Australia maintains a variety of oceanographic observing systems, which contribute to GCOS and GOOS.

Australia's ocean observations derive from a mix of in situ and space-based systems. Ocean observations are collected by various government agencies and institutions in support of climate monitoring and prediction, weather forecasting and warning services, and ocean and coastal marine research.

The Bureau of Meteorology is responsible for the management and operation of the in situ ocean surface observing networks which provide data in real time for weather prediction, operational ocean analyses and forecasting. These networks include:

- Australia's contribution to the international Voluntary Observing Ship scheme;
- drifting buoys deployed in the oceans surrounding Australia; and
- in conjunction with CSIRO Marine Research and the Royal Australian Navy, the Australian expendable bathythermograph ship-of-opportunity program.

CSIRO's Marine Research division also operates several research-based in situ ocean observing systems. In conjunction with the Bureau of Meteorology, CSIRO's Marine Research division is also participating in the international Argo network, deploying autonomous profiling floats off the west coast of Australia. The National Tidal Facility manages and operates Australia's sea-level monitoring network, and, with the member countries of the South Pacific Forum, manages a network of stations in 11 Pacific island countries. The Australian Antarctic Division, in conjunction with the National Tidal Facility and the Australian Surveying and Land Information Group, operates a network of specially designed tide gauges at Australian bases in Antarctica and on sub-Antarctic islands.

Australia is proposing to deploy a surface mooring within the next five years, and Australia's contribution to an Automated Shipboard Aerological Program in the Southern Hemisphere commenced during 2001.

In general, Australian oceanographic observing practices follow the GCOS/GOOS climate monitoring principles. Operational elements of the various networks are considered part of an integrated, multi-purpose system, which includes climate monitoring.

The Australian Oceanographic Data Centre is formally responsible for archiving and distributing Australian oceanographic data, with the Bureau of Meteorology responsible for marine data. The National Tidal Facility maintains extensive sea level data sets from Pacific and Indian Ocean sites and from the Association of South East Asian Nations (ASEAN) region. Australia adheres to the principles of free and unrestricted exchange of its ocean climate data.

Regular monthly analyses of the upper ocean temperature field are produced by the Joint Australian Facility for Ocean Observing Systems, which also acts as the World Ocean Circulation Experiment (WOCE) Indian Ocean Upper Ocean Thermal Data Assembly Centre. All upper ocean thermal data in the Indian Ocean for the WOCE period (1990 – 1997) are currently being assembled and provided with scientific quality control before analysis on ocean basin scales. This work also contributes to the Global Temperature Salinity Profile Program of the Joint Commission for Oceanography and Marine Meteorology/International Oceanographic Data and Information Exchange.

Australia participates in all international Panels related to the global ocean observing system. The Bureau of Meteorology participates on international buoy committees and is currently represented by the Chairman of the Data Buoy Cooperation Panel and, separately, by the Chairman of the International Buoy Program for the Indian Ocean.

Terrestrial observations

Australia also contributes to the GCOS and GTOS programs for terrestrial observations. Having no permafrost regions within its purview, Australia makes no contribution to the Global Terrestrial Network – Permafrost (GTN-P), but through its Antarctic Science Program, Australia contributes to the Global Terrestrial Network - Glaciers (GTN-G) by monitoring the fluctuations of glaciers on sub-Antarctic Heard Island. Responsibility for this activity rests with the Australian Antarctic Division. Australia has also begun initial implementation of its contribution to the Global Terrestrial Network – Carbon (GTN-C / FLUXNET). The Australian Oznet project is operated by CSIRO Land and Water, in conjunction with several Australian universities.

A four-year assessment of Australia's soil, water and vegetation resources, the National Land and Water Resources Audit, is currently being completed. The Audit aims to provide a framework for monitoring Australia's land and water resources in an ongoing and structured way. In fulfillment of this objective, the Audit will recommend an appropriate set of institutional arrangements and processes for ongoing monitoring and provide guidelines for the ongoing maintenance and updating of a range of physical and biological data sets. This process will strengthen Australia's contribution to global terrestrial observing systems, including the newly established Global Terrestrial Network – Hydrology (GTN-H).

Space-based observations

Australia is an active user and major contributor to research, development and applications in relation to space-based observing systems used to derive climate-related information. Australian activities in support of international space-based observing programs include:

- membership of international coordinating bodies such as the Committee for Earth Observation Satellites;
- development and construction of satellite hardware;
- provision of ground stations for the reception of satellite data and satellite orbit determination; and
- active involvement in various calibration/validation programs, including participation in the Along Track Scanning Radiometer series of satellite instruments onboard the European Space Agency's satellites (ERS-1, ERS-2 and ENVISAT) and involvement by CSIRO, the Australian Institute of Marine Science and the Bureau of Meteorology in ongoing validation studies for satellite instruments.

The Bureau of Meteorology maintains an accessible archive of satellite data of potential use in climate studies over a period of about 20 years. The archive primarily includes data from GMS (from the late 1970s) and the National Ocean and Atmospheric Administration (NOAA) series of meteorological satellites. There are three other main archives of meteorological and oceanographic satellite data in Australia. The CSIRO Office of Space Science and Applications Earth Observation Centre in Canberra has an archive of Advanced Very High Resolution Radiometer (AVHRR) data dating back to the early 1990s and is currently working on a project to composite orbits received from different reception stations. The other main archives of satellite data (NOAA, AVHRR and Sea-viewing Wide-Field Sensor (SeaWiFS)) are held by the Australian Institute of Marine Science in Townsville and the Western Australian Satellite Technology and Applications Consortium at the Leeuwin Centre in Perth. The latter archive goes back to 1981.

Support for developing countries to establish and maintain observing systems

Australia continues to provide significant technical advice and assistance to neighboring countries in the Asia-Pacific region to support the improvement of climate data management and monitoring capabilities.

The South Pacific Sea Level and Climate Monitoring Project, initiated in response to Pacific island leaders' concerns over the potential impact of climate change and sea level rise on Pacific island countries, is a long-term project which monitors sea level at 11 sites in the Pacific to an accuracy that is capable of detecting variations as small as 1mm per year. The project, which is funded by the Australian Agency for International Development (AusAID) and managed by the National Tidal Facility, contributes to the world wide sea level monitoring effort and also includes capacity building and public awareness. This project is now in its third five-year phase and the aim is to achieve a twenty-year sea level data record. Further detail of this project is set out in *Chapter 7 – Financial Resources and Transfer of Technology*.

Between 1999 and 2000, the Bureau of Meteorology participated in the WMO Climate Database Management System Project, which aims to identify candidate climate database systems that will satisfy the broad needs of WMO's member countries. Fourteen countries, including Australia, offered their national climate database for testing against performance criteria for data entry, ingestion, data validation and quality control, data extraction, metadata management, database administration and standard output product.

The BMRC, with assistance from CSIRO's Atmospheric Research division, hosted the second Asia-Pacific Network Workshop on Climate Extremes in December 1999. A major aim of the meeting was to plan the development of climate extremes indices within the region for the IPCC Third Assessment Report. The meeting was designed to allow participants from 15 countries to analyse their national daily climate data for changes in climate extremes. The meeting has become the model for a number of similar workshops, which have been held in Africa and the Caribbean.

Several scientists from the Bureau of Meteorology participated in the planning, content and conduct of the first GCOS Regional Implementation Workshop in Samoa in August 2000, a consequence of a decision of the Fifth Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) aimed at assisting developing countries in improving their climate monitoring systems.

A draft *Strategic Plan for the Development of Meteorology in the Pacific Region (2000 – 2009)*, which was prepared by South Pacific Regional Environment Program (SPREP) and the WMO Subregional Office for the South-West Pacific in Apia, with the assistance of the Bureau of Meteorology, was endorsed by the heads of National Meteorological Services of all 26 SPREP countries in July 1999 and approved by the October 1999 South Pacific Forum. As a follow up to the needs analysis, a project design document for the provision and application of climate prediction to a number of South Pacific island countries was prepared in June 2001 by the Bureau of Meteorology. This project focuses on one of the most urgent needs identified in the needs-analysis.

Further detailed information on Australia's meteorological, atmospheric, oceanographic and terrestrial climate observing systems can be found in Australia's national communication to the UNFCCC on systematic observation, *Australia's Global Climate Observing Systems – A Detailed National Report on Systematic Observation of Climate*, prepared by the Bureau of Meteorology and available from its website at **http://www.bom.gov.au**.

CHAPTER NINE

EDUCATION, TRAINING AND PUBLIC AWARENESS

Governments within Australia recognise that community understanding of the implications of climate change for Australia is a prerequisite for support of climate change initiatives and national greenhouse response action. Fostering this understanding is one of the overarching goals of Australia's National Greenhouse Strategy.

The level of promotional and educational activity related to climate change has increased significantly during the past five years. All levels of government, as well as industry and non-government agencies, are actively involved in awareness raising and education and training programs. Many of Australia's greenhouse policies and measures have education, training or communications-related elements. The examples provided in this chapter illustrate the breadth of activity being undertaken.

EDUCATION AND TRAINING

Primary and secondary schools

Under Australia's federal system, responsibility for school education resides with the States and Territories.

National commitment to greenhouse-related objectives in schooling is anchored in Goal 1.7 of *The Adelaide Declaration on National Goals for Schooling in the Twenty-First Century*, endorsed by all State, Territory and Commonwealth Ministers of Education in April 1999. The Declaration states that when students leave schools they should have 'an understanding of, and concern for, stewardship of the natural environment, and the knowledge and skills to contribute to ecologically sustainable development.' This statement significantly strengthens the commitment to environmental education provided in the earlier (1989) statement of national schooling objectives that it superseded. All States and Territories have also endorsed a national framework for greenhouse education under the National Greenhouse Strategy.

The Commonwealth Government has supported and worked with States and Territories by providing support and materials to promote greenhouse education in schools. For example, the Australian Greenhouse Office has developed a school resource kit that has been distributed nationally through the Australian Science Teachers Association and sponsored the development of curriculum materials by professional teachers' associations, including materials for English as a Second Language. It also coordinated a series of visits to schools throughout the south-east of Australia to engage students in thinking about climate change and about actions that they could take to reduce greenhouse emissions.

The Commonwealth Government's Natural Heritage Trust funds Airwatch, a national schools program coordinated through Western Australia's Department of Environment Protection. This hands-on monitoring program focuses on air quality but incorporates related issues such as global warming and the depletion of the ozone layer. Since 1998 more than 1 000 teachers throughout Australia have been introduced to Airwatch.

The Victorian Government, with funding contributions from the Queensland and Western Australian governments and the Energy Management Taskforce of the Australian and New Zealand Minerals and Energy Council (ANZMEC) – has developed the Australian Greenhouse Calculator. This calculator, available on the internet and CD-Rom, allows users to calculate annual greenhouse emissions, annual energy costs and annual energy-related non-greenhouse air pollution associated with daily household activities, such as energy consumption, transport use and waste disposal. It also contains general information about the greenhouse effect and climate change. The calculator is available online at **http://www.epa.vic.gov.au/greenhousecalculator**.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) produces a range of educational materials for schools as well as conducting classroom presentations. Tens of thousands of students are accessed through its magazines, *The Helix*, *Scientriffic* and *Ecos*, all of which have featured stories on climate change, renewable energy and energy efficiency.

An Environmental Briefings series is being conducted in each State and Territory as part of the National Education Program of the Minerals Council of Australia. The series is aimed at providing teachers with views on the issue of energy, greenhouse and climate change from academic, government and industry sectors. The series is being supported by the Commonwealth Department of the Environment and Heritage, the Australian Capital Territory (ACT) Department of Education, the Australian Science Teachers' Association, CSIRO and the National Science and Technology Centre.

The University of New South Wales's Sustainable Living Competition, conducted by the Faculty of the Built Environment, aims to engage high school students throughout Australia in identifying environmental problems and designing innovative solutions. Through its partnership with the Australian Greenhouse Office, the University is developing a range of resource materials for teachers and students.

Following are some examples of specific initiatives taken by States and Territories:

- In New South Wales (NSW), schools will be required from 2002 to develop environmental management plans that incorporate environmental concerns into school curriculum as well as management of resources and grounds. Many schools are addressing climate change issues across all components of the management plans. NSW also runs a Solar in Schools program that incorporates solar energy into the school's energy needs and curriculum. Schools involved in the program receive curriculum guides and a grid-connected solar system. NSW is continuing to develop the Greenhouse Action Program through its SCRAP (School Communities Recycling on Paper) program. About 40 schools have been involved in this program which teaches students how to conduct energy audits of their school and to identify and implement greenhouse reduction strategies. Students also learn about the role of plants in the enhanced

greenhouse effect through tree planting exercises in local parks using indigenous seedlings. Similar programs have been piloted in Victoria and in Queensland.

- In Victoria, climate change is a specific component of study in the Victorian Certificate of Education subject, Environmental Science. The Energy Smart Schools Program assists Victorian schools to introduce energy management programs and improve the energy efficiency of school facilities. The Victorian Government has also prepared a booklet – Understanding Climate Change – for distribution to all secondary schools and municipal libraries.
- The ACT has developed an Eco-Schools manual, which includes material on the enhanced greenhouse effect. As part of the Minerals Council of Australia's National Education Program, the first of a series of five environmental briefings on energy, greenhouse and climate change has been held for secondary teachers in the ACT and surrounding region.

Tertiary education

Progress is being made in incorporating greenhouse-related elements into relevant areas of vocational education and training curricula. For example, the Australian Greenhouse Office is funding projects aimed at incorporating sustainable energy principles into national training packages. It is also funding the conduct of studies aimed at identifying greenhouse-related training priorities for the building and construction industry and for resource managers and forest growers.

NSW has established an Energy Smart Trades Program to increase awareness in the trades of the economic and greenhouse benefits that can be realised through the use of sustainable energy. Strategies to incorporate greenhouse consideration into Technical and Further Education (TAFE) courses have also been developed.

In Victoria, a number of agencies are working with the TAFE sector and relevant industry training boards to develop environmental competency standards for a range of training programs, including on greenhouse and energy issues.

Universities are also giving increased emphasis to greenhouse-related issues in their course offerings and community service as well as in their research. For example:

- A number of universities are offering courses in renewable energy and related areas through the Australian Cooperative Research Centre for Renewable Energy, as well as on their own account.
- The MSA Green Steps Project, managed by Monash University Students Association, is aimed at training university students in environmental change management while developing energy efficiency and waste minimisation strategies at Monash University and in business around Melbourne through student placements. The program offers a unique combination of education, training, community outreach and business involvement.
- In Western Australia, the State's electricity utility Western Power sponsors a degree course in renewable energy engineering at Murdoch University to provide professional engineers with the specific skills to put renewable energy systems into application.

The Australian Greenhouse Office also administered the Management of Graduate Placement Pilot Program, which ran between 1997 and 1998. Under this program, university graduates were placed with companies wishing to develop cooperative agreements under the Greenhouse Challenge program. The graduates were placed in a range of sectors, including petroleum, food, services, manufacturing and chemicals and local government, in order to facilitate education and training.

Ongoing education and training

Support for ongoing education and training in greenhouse-related areas features prominently in the development of a wide range of greenhouse programs.

The Australian Greenhouse Office is supporting the Master Plumbers and Mechanical Services Association of Australia to pilot its Green Plumber initiative, through which 500 plumbers will be trained in how to advise their customers about the most energy efficient heating and cooling appliances and hot water products. The initiative is being backed by some of Australia's biggest manufacturers of heating and cooling and hot water products, including Robert Bosch Australia, Southcorp Water Heaters Australia (Rheem), Rinnai, ILEC Appliances (Vulcan), AGL and Seeley International (Braemar).

The Australian Greenhouse Office has also developed a web-based training and resource kit for energy/property managers (together with a building energy evaluation methodology). Following widespread interest, the kit (which was initially targeted to Commonwealth agencies) is being enhanced to meet the needs of all levels of government and of industry. The Australian Greenhouse Office is also developing a range of technical support materials in areas such as transport, waste and energy efficiency are being developed to assist local governments to identify ways to influence change, and reduce greenhouse gas emissions within their communities.

Wherever possible, grants provided under the Australian Greenhouse Office's Renewable Energy Commercialisation Program incorporate training and education activities. Examples of activities which are being funded include:

- training professionals by the University of Melbourne in photovoltaics, as part of a project to design and develop Australia's first large-scale building-integrated photovoltaic solar power generation project;
- training trades people and local government in designing and installing PV, as part of a major building demonstration site for specific solar energy products and building-integrated solar photovoltaics in the Kogarah Town Centre; and
- training members of indigenous communities in the operation and monitoring of PV Solar Arrays, as part of a project to install 200kW Grid Feed Sun Farm for the Anangu Pitjantjatjara Lands, in the far north-west corner of South Australia.

In collaboration with industry, the Australian Greenhouse Office has developed a training and accreditation program for designers and builders and produced guides on energy efficiency, environmental and town planning issues relating to the design and construction of houses in different climate zones of Australia. The Housing Industry Association is working with the Australian Greenhouse Office and Greening Australia (through Partnerships Advancing the Housing Environment (PATHE)) to conduct a two-day training and accreditation courses on building in an environmentally friendly way. PATHE also operates a GreenSmart Village that serves as a learning site for building professionals as well as a display village to inform consumers about all aspects of building including appropriate and efficient appliances.

PUBLIC AWARENESS RAISING

Australia is working actively to raise community awareness of greenhouse issues. A range of approaches are being adopted, including generic public information campaigns, the establishment of resource and information centres, public promotion of particular initiatives and the activities of community organisations. The impact of Australia's activities also extends internationally.

Public information and education

The Commonwealth Government conducted a nationwide public information campaign during February 2001 to raise awareness of the greenhouse issue as well as actions that individuals can take to contribute to national efforts to reduce greenhouse emissions. The campaign, conducted through television, newspaper and magazine advertising, was supported by a telephone information line and the Australian Greenhouse Office's publication, *Global Warming Cool it! A home guide to reducing energy costs and greenhouse emissions*, which can be accessed online at **http://www.greenhouse.gov.au/pubs/gwci/index.html**.

Commonwealth Government departments and agencies also produce a range of publications aimed at keeping industry and the general community informed of greenhouse-related initiatives, success stories and developments in national and international policy. *Greenhouse News*, produced by the Australian Greenhouse Office, and *Australian Energy News*, produced by the Department of Industry Science and Resources, are just two examples.

Australian scientific institutions play a pivotal role in disseminating current information to increase public awareness about the science of climate change through initiatives ranging from public lectures and seminars, university and school education, distribution of publications, media activities and training courses. Australia's Intergovernmental Panel on Climate Change (IPCC) Lead Authors have played a key role in disseminating the findings of the IPCC Third Assessment Report through industry and public briefings as well as media coverage.

The CSIRO conducts a National Awareness Program to raise awareness of the importance of science and technology to Australia's future. Issues such as climate change are promoted through this program which includes *The SciFiles* radio program which is broadcast by 250 radio stations across Australia each month and the Australia Advances television series which is made available free to all networks and has an audience of over four million people. The National Science Briefings for parliamentarians, their advisers and the media are provided by CSIRO on a range of topics including climate change.

The Bureau of Meteorology is actively involved in disseminating public information materials both online and offline. The Bureau conducts regular presentations to industry, government, academia and industry on international scientific findings and the climate change science-policy interface. It also maintains a high media presence on issues related to climate change and climate observation and monitoring.

A key component of the Australian Greenhouse Science Program, coordinated by the Australian Greenhouse Office, has been the development and implementation of a communication strategy through its partner organisations. The strategy ensures that key developments in greenhouse science, including the release of the IPCC Working Group Reports and the release of regional scenarios by CSIRO, are communicated through the media, websites, information materials and seminars and workshops to people in industry, business and the government, as well as the wider public. The program has also coordinated two climate change briefings for the Prime Minister's Science, Engineering and Innovations Council.

States and Territories have also played a role in public awareness raising. NSW and Victoria have conducted extensive media campaigns, targeted at increasing public awareness of climate change and energy efficiency.

A substantial part of Australia's promotional activity has addressed sectoral issues related to climate change, such as energy efficiency, sustainable transport and land management, rather than greenhouse specifically. For example, extensive information on natural resource management issues has been generated through the Australian Government's Natural Heritage Trust, which has conducted vigorous television and magazine

advertising to promote integrated natural resource management through the development and use of better management practices.

The Reach for the Stars program, an initiative of the Commonwealth, Victorian and NSW Governments, promotes the purchase of energy efficient appliances through major appliance retailers in NSW and Victoria. Based on the energy rating labels found on gas and electrical appliances, the program enables customers to make informed choices when purchasing these goods. Through educated sales staff and in-store literature, customers are able to compare the energy use and running cost savings of different appliance models by using the energy-rating label.

The ACT's Canberra Bicycle 2000 Strategy addresses the promotion of safe cycling, individual health and urban planning. The ACT is also promoting sustainable transport options through the distribution of information products and its Voluntary Travel Behaviour Change program.

The Western Australian Government is assisting local councils and their communities to promote travel alternatives through the TravelSmart program. TravelSmart targets community organisations, schools and workplaces and is showing positive results with reductions in car use and increases in walking, cycling and public transport use.

LINKING PUBLIC AWARENESS RAISING TO POLICIES AND MEASURES

By incorporating public awareness goals into specific policies and measures, the Commonwealth Government aims to increase the acceptance and understanding of climate change as a significant and real issue to the public and consumers. Examples of this approach include:

- the Greenhouse Friendly program, which aims to raise public awareness on climate change by providing opportunities for consumers to consider greenhouse when making their purchasing decisions through greenhouse certification and labelling of products and services;
- the Cool Communities project, delivered by the Australian Greenhouse Office, in conjunction with environmental community groups from each State and Territory. Through this project, householders are provided with information and resources to help them take action on greenhouse;
- the National Appliance and Equipment Energy Efficiency Program, which raises consumer awareness of the energy intensity of appliances and equipment through comparative energy labelling and minimum energy performance standards for domestic appliances, commercial products and industrial equipment; and
- the Fuel Consumption Labelling Scheme, which aims to raise awareness of fuel efficient cars and their role in helping to reduce greenhouse gas emissions.

For further details on these policies and measures refer to *Chapter 4 – Policies and Measures*.

Resource and information centres

The Australian Greenhouse Office operates a telephone information service that can be accessed nationally for the cost of a local call. The telephone service provides the general community with access to publications, Australian government climate change program information and advice on actions to reduce greenhouse emissions. It is supported by a comprehensive website that provides detailed information on Commonwealth climate change programs.

Consumer information on Australia's energy rating scheme for electrical and gas appliances, energy award programs and fuel label consumption program for motor vehicles can also be accessed online at:

http://www.energystar.gov.au/

http://www.energyrating.gov.au/

http://www.greenhouse.gov.au/fuellabel/index.html

http://www.greenhouse.gov.au/transport/fuelguide/

A number of States and Territories have created energy information centres that provide information on government energy policies and programs, energy safety and publications, as well as advice on a wide range of energy saving ideas for consumers and businesses.

YOUR HOME

The Commonwealth Government and the building and design industries have worked together to develop a suite of guide materials to encourage good environmental design of residential buildings. *Your Home* aims to encourage consumers, designers and builders to apply Environmentally Sustainable Design principles when designing, building, purchasing or renovating a home.

The project includes:

- an easy to read magazine-style guide for consumers, presenting basic information about good environmental residential design and renovation;
- a series of technical materials and case studies providing the 'how to' information for designers, builders, and interested consumers;
- a CD-ROM containing electronic versions of both the Consumer Guide and the Technical Manual; and
- a dedicated interactive website making all materials available online at http://www.yourhome.gov.au/.

Contribution of non-governmental organisations

The Australian community has become more aware of the significance of climate change as an issue. The broad range of non-governmental organisations (NGOs) that are actively involved in promoting public awareness and understanding of greenhouse issues through research, lobbying, education and training and media activities has contributed to this greater awareness. These NGOs, which cover all sectors of the Australian economy, range from peak professional associations, industry and business organisations, conservation and community groups and environment centres. To take a few examples:

- The National Farmers Federation keeps its members informed of climate change issues and its likely impacts on the rural sector through newsletters, seminars and conferences. The Federation is also a member of the national Greenhouse and Agriculture Taskforce, which was established to encourage information exchange between agricultural sector representatives, policy makers and researchers and to encourage the uptake of actions to reduce greenhouse gas emissions.
- PATHE, developed by the Housing Industry Association in collaboration with the Commonwealth Government and Greenhouse Australia, promotes technologies, design principles and practices that can significantly improve the quality of Australia's built environment. PATHE distributes a quarterly newsletter to its members and the general public and is active in educating consumers that 'green' houses are more comfortable and cheaper to run.

- Electrical appliance manufacturers and retailers are also involved in communicating the benefits of energy efficiency to consumers through the Reach for the Stars program mentioned above.
- The motor vehicle industry provides consumer information on the fuel efficiencies of different makes of motor vehicles and energy-efficient driving practices.
- Many conservation groups have been active in working with the community on environmental issues that have positive greenhouse outcomes. For example, Smogbusters, an initiative between the Community Conservation Council and the Commonwealth Government, is working with the community to improve urban air quality by encouraging the use of more environmentally friendly forms of transport such as walking, cycling, bus, train and tram use.
- Community environmental centres are encouraging grassroots interest in the issue of climate change. The CERES Community Environmental Park in Victoria has integrated climate change, social, economic and sustainability issues through its interactive displays and education and website materials. Many other community centres throughout Australia are modelling themselves on the CERES example.
- Solar vehicle races have become popular items on event calendars and have been effective in promoting the benefits of energy efficiency and an increased awareness of global warming. Organised by independent companies, these events, are conducted across Australia and attract sponsors from industry and government and competitors from schools and universities, the general public and industry. Millions of people throughout Australia and internationally watch, read or hear about these events through media and promotional exposure.

The non-profit sector is also involved in educating school students about climate change issues. For example:

- Planet Ark, in conjunction with the Australian Association for Environmental Education, has produced an education kit for primary school students (entitled Do Something). This kit is accompanied by a video that has been marketed to the general community through national video stores.
- The Foster Foundation has run a series of Carbon Awareness Days for secondary school students and is developing curriculum materials focusing on climate change and air quality issues.

Public consultation

Public consultation has been a hallmark of the development of the Australian Government's policies and programs relating to climate change. A number of mechanisms are provided to enable the public to comment on and have input into policy development.

A range of high level and expert groups and taskforces, comprised of government, industry, scientific and community representatives, advise on issues such as measures to encourage the use of energy efficient appliances, initiatives to foster the renewable energy industry and the introduction of energy efficiency labels for motor vehicles.

Discussion papers canvassing a range of issues, from energy efficiency to emissions trading, are circulated to relevant industry, peak professional, scientific and community groups for input and feedback.

The Commonwealth Senate Inquiry on Global Warming provided an opportunity for industry, community groups and government agencies to have input into development of domestic climate change policy. This wide-ranging inquiry, held over 15 months during 1999 and 2000, included 13 public hearings conducted in capital cities throughout the country. During the course of the hearings, the Committee took evidence from 65 organisations, 10 State and Commonwealth Government departments and heard from 161 individual witnesses. Public submissions to the inquiry totalled 227. Following the inquiry, the Senate Environment, Communication, Information Technology and the Arts References Committee presented its findings to

Parliament in its report, *The Heat is On: Australia's Greenhouse Future*. In 2001 the Commonwealth Government formally responded to the report's more than 100 recommendations. A copy of the Government's response can be viewed online at **http://www.greenhouse.gov.au/pubs/senateinquiry/**.

International activities

In a number of cases, the impact of Australia's promotional activities has extended well beyond its own borders. For example, Australia hosted the world's first Green Olympics in Sydney during September 2000, establishing the environment as the third pillar of the Olympic movement alongside sport and culture. The Sydney Olympics showcased to the world building designs incorporating low energy principles and solar power and water recycling. The 2000 Olympic Games demonstrated how environmental principles such as recycling and sustainable transport can be integrated in modern living and provided the environmental blueprint for staging major sporting or cultural events anywhere in the world. For further details refer to *Chapter 4*.

The international spotlight was once again on Australia in Year 2000 as the host of United Nations World Environment Day, which provided another opportunity to showcase our expertise and achievements across a range of environmental issues, including global warming. Australia also hosted the International Solar Energy Society's 2001 Solar World Congress in Adelaide.

Leading Australian sustainable technologies, such as the hybrid car developed by CSIRO, have been promoted at major international exhibitions including EXPO 2000, the World Exposition held in Hannover, Germany, which attracted more than 18 million people.

Australia also makes a contribution to the international arena through its funding of bilateral and regional activities that strengthen climate change capacity building, information networks, training and research in developing countries, predominantly in the Asia-Pacific region. For further details on these funding activities refer to *Chapter 7 – Financial Resources and Transfer of Technology*.

ACRONYMS AND ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
ACIAR	Australian Centre for International Agricultural Research
ACOS	Australian Climate Observing System
ACT	Australian Capital Territory
AGO	Australian Greenhouse Office
AIJ	Activities Implemented Jointly
ANZMEC	Australian and New Zealand Minerals and Energy Council
AOOS	Australian Ocean Observing System
APACE	Appropriate Technology for Community & Environment Inc.
ASEAN	Association of South East Asian Nations
AusAID	Australian Agency for International Development
AVHRR	Advanced Very High Resolution Radiometer
BAU	business-as-usual
BMRC	Bureau of Meteorology Research Centre
BoM	Bureau of Meteorology
BTE	Bureau of Transport Economics
CASE	International Centre for Application of Solar Energy
CCP™	Cities for Climate Protection™
CDM	Clean Development Mechanism
CH_4	methane
CIE	Centre for International Economics
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent

COAG	Council of Australian Governments
CoPS	Centre of Policy Studies
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
EBRD	European Bank for Reconstruction and Development
EEBP	Energy Efficiency Best Practice and Benchmarking Program
ENSO	El Niño Southern Oscillation
ENVISAT	Environment Satellite
ERS	Earth Resources Satellite
GAW	Global Atmosphere Watch
GCM	Global Climate Model
GCOS	Global Climate Observing System
G-Cubed	Global General Equilibrium Growth Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GES	Generator Efficiency Standards
Gg	gigagram (one thousand grams)
GGAP	Greenhouse Gas Abatement Program
GMI	Global Meat Industry
GMS	Geostationary Meteorological Satellite
GOOS	Global Ocean Observing System
GSN	GCOS Surface Network
GST	goods and services tax
GTEM	Global Trade and Environment Model
GTN-C	Global Terrestrial Network - Carbon
GTN-G	Global Terrestrial Network - Glaciers
GTN-H	Global Terrestrial Network - Hydrology
GTN-P	Global Terrestrial Network - Permafrost
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper Air Network
GWh	gigawatt hour
GWP	Global Warming Potential
HFC	hydrofluorocarbon
HIPC	Highly Indebted Poor Country Initiative
HLGG	High Level Group on Greenhouse
IBRD	International Bank for Reconstruction and Development
IDA	International Development Agency
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IGBP	International Geosphere-Biosphere Programme
IGP	Industry Gross Product
IGP	International Greenhouse Partnerships
IHDP	International Human Dimensions Program
IMF	International Monetary Fund
Inventory	National Greenhouse Gas Inventory
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
km	kilometre
km^2	kilometre squared
kW	kilowatt
LNG	liquefied natural gas
LPG	liquefied petroleum gas
m	metre
MEPS	Minimum Energy Performance Standards
MIGA	Multilateral Investment Guarantee Agency
mm	millimetre

MMA	McLennan Magasanik Associates
MMRF-Green	Monash Multi-Regional Forecasting-Green
MRET	Mandatory Renewable Energy Target
Mt	megatonne (one million tonnes)
Mt CO_2-e	million tonnes of greenhouse house gas emissions expressed as units of CO2
MW	megawatt
N_2O	nitrous dioxide
NAP	National Action Plan for Salinity and Water Quality
NCAS	National Carbon Accounting System
NEM	National Electricity Market
NGGI	National Greenhouse Gas Inventory
NGGIC	National Greenhouse Gas Inventory Committee
NGO	Non-governmental organisation
NHT	Natural Heritage Trust
NIEIR	National Institute of Economic and Industry Research
NMVOC	non-methane volatile organic compounds
NOAA	National Ocean and Atmosphere Administration
NO_x	oxides of nitrogen
NSS	National Strategy Studies
NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic Cooperation and Development
PATHE	Partnerships Advancing the Housing Environment
PFC	perfluorocarbon
PICCAP	Pacific Island Climate Change Assistance Program
PJ	petajoule
PNG	Papua New Guinea
ppm	parts per million
PRGF	Poverty Reduction and Growth Facility
Qld	Queensland
S&T	States and Territories
SA	South Australia
SEAV	Sustainable Energy Authority of Victoria
SeaWIFS	Sea-viewing Wide-Field Sensor
SEDA	Sustainable Energy Development Authority
SF6	sulphur hexafluoride
SIDS	Small Island Developing States
SO_2	sulphur dioxide
SOPAC	South Pacific Applied Geoscience Commission
SPREP	South Pacific Regional Environment Program
TAFE	Technical and Further Education
Tas	Tasmania
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
Vic	Victoria
WA	Western Australia
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
$	Australian dollars, unless otherwise specified
4WD	four-wheel drive


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