



Climate Change

*Australia's Second
National Report under
the United Nations
Framework Convention
on Climate Change*

NOVEMBER 1997



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Preface

Australia, along with over 150 other countries, signed the United Nations Framework Convention on Climate Change in June 1992 and became the ninth country to ratify the Convention in December 1992.

Australia submitted its first National Communication in September 1994. This second National Communication sets out how Australia, as an Annex I Party to the Convention, is continuing to advance its international obligations. It provides an overview of the national circumstances that influence Australia's response capacity and an update on both the continuing and additional strategies and measures that have been taken up to address the enhanced greenhouse effect. The measures and projections presented were current in mid 1997.

The National Greenhouse Strategy provides the main framework for Australia's approach to addressing emissions of greenhouse gases. Progress in implementing its greenhouse gas abatement measures was described in the first National Communication. This is a dynamic strategy, and since its adoption in 1992 many additional measures with a significant impact in limiting emissions have been identified and launched. The successful Greenhouse Challenge Program of voluntary agreements for industry, detailed in Chapter 4, 'Policies and measures', is one example.

Monitoring and reviewing of the implementation of measures are critical features of the National Greenhouse Strategy. During 1996 and 1997 a major strategic review of the Strategy, involving all spheres of government, has been taking place. The Council of Australian Governments will be proceeding to finalise the new National Greenhouse Strategy which is an outcome of this review. It will be completed by mid 1998.

Since completion of this Communication, the Prime Minister has announced a package of strengthened Commonwealth response actions in recognition of the importance placed by Australia on the need to continue advancing efforts on the abatement of greenhouse gas emissions. The measures contained in the strategy, 'Safeguarding the future: Australia's response to climate change', are highlighted in Chapter 4, 'Policies and Measures'. However, they are not included in the projections presented in Chapter 5.





Abbreviations

AAD	Australian Antarctic Division	CASE	Centre for Application of Solar Energy
ABARE	Australian Bureau of Agricultural and Resource Economics, whose models are named MEGABARE and GIGABARE	CF ₄	tetrafluoromethane
ACA	Australian Coal Association	CFC	chlorofluorocarbon
ACE-1	Coordinated Aerosol Characterisation Experiment	CH ₄	methane
ACIAR	Australian Centre for International Agricultural Research	CLIVAR	Climate Variability and Predictability
ACSYS	Arctic Climate System Studies	CNG	compressed natural gas
ACT	Australian Capital Territory	CO	carbon monoxide
ACTU	Australian Council of Trade Unions	CO ₂	carbon dioxide
AEEI	Autonomous Energy Efficiency Improvement	CoAG	Council of Australian Governments
AGSO	Australian Geological Survey Organisation	COMCIAM	Climate Impact Assessment and Management Program for Commonwealth Countries
AIJ	Activities Implemented Jointly	CRC	Cooperative Research Centre
AIMS	Australian Institute of Marine Science	CRC SHM	Cooperative Research Centre for Southern Hemisphere Meteorology
AMIP	Atmospheric Model Intercomparison Project	CSIRO	Commonwealth Scientific and Industrial Research Organisation
ANSTO	Australian Nuclear Science and Technology Organisation	CTI	Climate Technology Initiative
ANZECC	Australian and New Zealand Environment and Conservation Council	DEBITS	Deposition of Biogeochemically Important Trace Species
APEC	Asia-Pacific Economic Cooperation	DPIE	Department of Primary Industries and Energy
ASEAN	Association of South-East Asian Nations	EA	Environment Australia
ATC	Australian Transport Council	EMABA	Econometric Model of Australian Broadacre Agriculture
AusAID	Australian Agency for International Development	ENSO	El Niño–Southern Oscillation
BHP	Broken Hill Proprietary Co. Ltd	EPA	Environment Protection Authority
BIOCLIM	Bioclimatic analysis and prediction modelling tool	ESCAP	Economic and Social Commission for Asia and the Pacific
BOM	Bureau of Meteorology	FANGIO	Feedback Analysis of Global Climate Models for Intercomparison with Observations
BRS	Bureau of Resource Sciences	FCCC	Framework Convention on Climate Change
BTCE	Bureau of Transport and Communications Economics	FES	Fuel and Electricity Survey
C ₂ F ₆	hexafluoroethane	FFP	National Farm Forestry Program
CADDET	Centre for the Analysis and Dissemination of Demonstrated Energy Technologies	GAIM	Global Analysis, Interpretation and Modelling
		GCM	global climate model
		GCOS	Global Climate Observing System
		GCTE	Global Change and Terrestrial Ecosystems

GDP	Gross Domestic Product	RD&D	Research, Development and Demonstration
GEF	Global Environment Facility		
GEWEX	Global Energy and Water Cycle Experiment	REIP	Renewable Energy Industry Program
GNP	Gross National Product	RFA	Regional Forest Agreement
GOOS	Global Ocean Observing System	RICE	Regional Interactions of Climate and Ecosystems
GWP	Global Warming Potential	SA	South Australia
HCFC	Hydrochlorofluorocarbon	SEDA	Sustainable Energy Development Authority of NSW
HFC	Hydrofluorocarbon	SEICA	Sustainable Energy Industries Council of Australia
ICLEI	International Council for Local Environmental Initiatives	SOCE	Southern Ocean Cloud Experiment
IGAC	International Global Atmospheric Chemistry	SOPAC	South Pacific Applied Geoscience Commission
IGBP	International Geosphere-Biosphere Programme	SPARC	Stratospheric Processes and their Role in Climate
INC	Intergovernmental Negotiating Committee	SPREP	South Pacific Regional Environment Program
IPCC	Intergovernmental Panel on Climate Change	START	Global Change System for Analysis, Research and Training
JGOFS	Joint Global Ocean Flux Study	TOGA	Tropical Oceans Global Atmosphere Experiment
LNG	liquefied natural gas	UNCED	United Nations Conference on Environment and Development
LPG	liquefied petroleum gas	UNDP	United Nations Development Programme
McTEX	Maritime Continent Thunderstorm Experiment	UNEP	United Nations Environment Programme
Mt	megatonne	UNIDO	United Nations Industrial Development Organisation
Mt CO ₂ -e	megatonne carbon dioxide equivalent	WA	Western Australia
N ₂ O	nitrous oxide	WCP	World Climate Programme
NAFC	national average fuel consumption	WCRP	World Climate Research Programme
NEEP	National Energy Efficiency Program	WMO	World Meteorological Organization
NFPS	National Forest Policy Statement	WOCE	World Ocean Circulation Experiment
NGGI	National Greenhouse Gas Inventory	WRP	Waste Reduction Plan
NGGIC	National Greenhouse Gas Inventory Committee		
NGRS	National Greenhouse Response Strategy		
NLP	National Landcare Program		
NMVOC	non-methane volatile organic compounds		
NO _x	oxides of nitrogen		
NSW	New South Wales		
OASIS	Observations at Several Interacting Scales		
ODA	official development assistance		
OECD	Organization for Economic Co-operation and Development		
OECD/IEA	OECD International Energy Agency		
PAGES	Past Global Changes		
PFC	perfluorocarbon		
PICs	Pacific Island Countries		
PILPS	Project for the Intercomparison of Land-Surface Parameterisation Schemes		
Qld	Queensland		
R&D	Research and Development		



Executive summary

Australia submitted its first National Communication in September 1994. This second National Communication sets out how Australia, as an Annex I Party to the Convention, is continuing to advance its international obligations. It gives an overview of the national circumstances that influence Australia's response capacity, and provides an update on both the continuing and additional strategies and measures that have been adopted to address the enhanced greenhouse effect. The measures and consequent projections are those that were current in mid 1997.

During 1996 and 1997 a major strategic review, involving all spheres of Government, has been taking place to develop a new National Greenhouse Strategy. This is expected to be agreed by all Australian Governments by mid 1998.

In recognition of the importance placed by Australia on the need to continue advancing efforts on the abatement of greenhouse gas emissions, the Prime Minister announced a package of strengthened Commonwealth response actions on 20 November 1997. These measures are summarised at the end of this chapter.

AUSTRALIA IN CONTEXT

Australia is in many respects unique among Annex I Parties:

- It is the lowest, the flattest and, apart from Antarctica, the driest of the world's continents, and has a wide range of climatic zones.
- A high level of rainfall variability is a characteristic of much of the continent. Extreme climate events such as droughts, floods, tropical cyclones, severe storms and bushfires occur regularly and require flexibility and adaptation.
- It has a rapidly increasing population.
- Vast distances separate urban centres within Australia, and even greater distances separate Australia from other countries.
- While most Annex I countries have relatively stable patterns of land usage, land use patterns in Australia are still undergoing significant change.
- Exports, particularly of primary products, energy and energy intensive manufactures, play a major role in the economy.

With a land area of more than 768 million hectares, Australia is the sixth largest country in the world. Its population was 18.4 million in 1996 and is projected to grow by 29.6% by 2020. This growth rate is higher than that of many OECD countries. Geography, patterns of urban settlement and trade patterns result in Australia having large requirements for national and international passenger and freight transport.

The structure of Australia's economy has a major impact on its greenhouse gas emissions profile, and consequently on its approach to addressing climate change. Australia is the fourteenth largest industrial economy in the world, with a gross domestic product (GDP) in 1996/97 of A\$510 billion (around US\$400 billion).

Agriculture currently accounts for nearly 30% of total Australian merchandise exports. Agricultural and pastoral properties in Australia cover more than 450 million hectares, or about two-thirds of the

land surface. In contrast to the situation in all but one other Annex I country, land use change and forestry is a net source of emissions with land use change for agriculture the main contributor.

Australia's forest resources comprise some 156 million hectares of native forest and woodland and one million hectares of plantations. Reflecting its unique and megadiverse fauna and flora, Australia has designated large areas for nature conservation with more than 60 million hectares of terrestrial parks and reserves and nearly 40 million hectares of marine and estuarine protected areas.

Australia is more dependent on fossil fuels than any other OECD country, primarily because low cost fossil fuels are abundant, hydroelectric resources are limited, and nuclear power is not utilised. The potential exists to make greater use over time of renewable energy sources such as wind, solar and biomass. In contrast to other OECD countries, Australia is a significant net energy exporter, with nearly 70% of total energy production supplied to overseas markets in 1995/96. Australia is the world's largest coal exporter and second largest uranium exporter, and exports of natural gas have also been increasing in recent years.

Along with a central Commonwealth Government, Australia has eight self-governing States and Territories and more than 700 Local Governments. The complexity of Australia's constitutional arrangements is evident in the implementation of greenhouse policy. While the Commonwealth can provide leadership and take part in international negotiations, State, Territory and Local Governments have responsibility in many areas related to the implementation of climate change policy.

NATIONAL GREENHOUSE GAS INVENTORY - EMISSIONS TRENDS 1990 TO 1995

Australia's greenhouse gas emissions profile is unique. Non-energy sectors are more significant for Australia's Inventory than for most other Annex I Parties, as is the contribution of methane.

In 1995 the Energy Sector accounted for nearly 65% of emissions (made up of Stationary Energy 46%, Transport 14% and Fugitive emissions 5%), Agriculture for nearly 18%, Waste for about 3%, Industrial Processes for about 2% and the Land Use Change and Forestry Sector for almost 12%.

Carbon dioxide (CO₂) contributes more than 72% and methane (CH₄) - predominantly from Agriculture and Fugitive emissions - nearly 23% of Australia's greenhouse gas emissions.

CO₂ emissions from the Energy Sector increased by almost 9% over the period 1990 to 1995. Total

Table 1.1 Net greenhouse gas emissions and changes by sector, 1990 and 1995 megatonnes carbon dioxide equivalent (Mt CO₂-e), excluding land clearing

Sector	1990 Mt CO ₂ -e	1995 Mt CO ₂ -e	Mt CO ₂ -e Change	% Change
1. All Energy	293.3	317.4	24.0	8.2
Stationary Energy	205.5	223.0	17.3	8.5
Transport	61.8	68.8	7.0	11.3
Fugitive	26.0	25.6	-0.4	-1.5
2. Industrial Processes	12.1	9.0	-3.1	-25.6
3. Solvent & Other Product Use	NA	NA	NA	NA
4. Agriculture	88.8	87.4	-1.5	-1.6
5. Land Use Change and Forestry (a)	-29.4	-27.6	1.8	-6.1
6. Waste	14.8	16.4	1.6	10.8
Total of above	379.6	402.6	22.8	6.0

Percentages may not add due to rounding.

(a) Excludes Forest & Grassland Conversion Subsector.

* Land clearing is equivalent to the Intergovernmental Panel on Climate Change (IPCC) Land Use Change and Forestry Subsector 'Forest and Grassland Convention' (5B).

CH₄ emissions decreased by almost 2% and emissions of perfluorocarbons decreased by almost 70% over the same period.

Australia's greenhouse gas emissions, excluding those from land clearing*, totalled the equivalent of 380 million tonnes (Mt) of CO₂ in 1990 and 403 Mt in 1995, an increase of about 6% (see Table 1.1).

The National Greenhouse Gas Inventory is a key priority under Australia's National Greenhouse Strategy. Since the first National Communication was published, a major review of methods used in all Sectors has been undertaken, with the outcomes published in a series of workbooks. Annual Inventories covering the period 1988 to 1995 have also been produced in accordance with domestic and international reporting commitments while taking into consideration Australia's specific circumstances.

In many instances, the methodology employed is more detailed than the IPCC default methodology. Considerable effort has been put into obtaining better input data and reducing uncertainty through the development of an improved understanding of the biosphere - in particular, the contribution of land clearing emissions. This work, together with revision of the Global Warming Potential (GWP) factors used to equate different greenhouse gases, has resulted in a lowering of annual emission figures compared with the corresponding values reported previously.

Nevertheless, estimates in the land clearing subsector still have a high level of uncertainty. For this reason, Australia's most recent National Greenhouse Gas Inventory, covering 1995, reports emissions associated with land clearing separately from the total greenhouse gas emissions. This document adopts the same change in approach from previous practice in reporting Inventory data.

In 1995, estimated emissions from land clearing totalled the equivalent of 85 Mt of CO₂, a decline of 38 Mt, or 31%, from the 123 Mt emitted in 1990.

The falling trend in land clearing emissions is influenced mainly by a reduction in the area of land cleared in the past decade and the diminishing effect of extensive past (1960s and 1970s) clearing on CO₂ emissions from the soil. The reduction in land clearing over time has resulted in decreased regrowth, and therefore reduced carbon sequestration.

The new methodology developed for estimating land clearing emissions incorporates three significant changes: a preliminary land use change model has been introduced, estimates of biomass density per hectare have been improved and woody vegetation has been included in calculations of regrowth for the first time.

Uncertainty estimates currently stand at about $\pm 30\%$ for the rate of change in area cleared and $\pm 40\%$ for change in carbon per unit area. These figures represent a major improvement in confidence, as the error for both components was previously estimated to be of the order of $\pm 50\%$. The revised methodology, which takes into consideration land use practices across Australia, and the acquisition of improved input data were the factors chiefly responsible for the improvement. Work is progressing to further reduce uncertainty in estimates of the area and rate of land clearing, and in biomass and soil carbon estimates.

POLICIES AND MEASURES

Australia's greenhouse policies and response measures are based on the comprehensive approach of addressing all sources and sinks of all greenhouse gases across all sectors of the economy.

The National Greenhouse Strategy, adopted in 1992, provides the principal framework for these policies and measures. This was developed by the Commonwealth, State and Territory Governments in partnership with the Australian Local Government Association, and was formally endorsed by heads of Government through the Council of Australian Governments.



Progress on implementation was reported in the First National Communication in 1994. Since then, a range of significant additional measures has been adopted to enhance greenhouse response efforts.

Australia has recognised that an effective national greenhouse response requires action by all spheres of Government, and by Governments in partnerships with industry and the broader community.

A significant number of initiatives and actions have been put in place to address emissions. Measures with major greenhouse gas reducing potential implemented in the stationary energy, transport and industrial areas include energy market reforms and the Greenhouse Challenge Program. Cogeneration and renewable energy are also being used increasingly by major energy consumers.

- A National Sustainable Energy White Paper is being developed. It will aim to set out a broad framework for energy policy, integrating economic and environmental objectives over a 25-year timeframe. Key elements will include energy market reform, conventional and alternative technologies (including renewable energy technologies), energy efficiency, research and development, international collaboration and institutional arrangements.
- Electricity industry reform has been taking place in Australia following agreement to establish a more competitive integrated national electricity market across the generation, retail and distribution sectors by 2001. The first stage began in Victoria, New South Wales (NSW) and the Australian Capital Territory (ACT) in 1997. South Australian generators will join the national market when the market systems are fully operational in 1998, while Queensland and Tasmania will join following grid interconnection. The reforms are expected to promote efficient competition in supply by embedded cogeneration and renewable energy sources, and more sensible patterns of energy use through incentives for investment in energy efficiency.
- Natural gas industry reform, through a recently finalised National Access Code, will promote the penetration of natural gas in the energy sector with consequent significant savings in greenhouse gas emissions.
- A targeted partnership program, the Greenhouse Challenge Program, has been established. So far, 100 agreements have been signed under this successful program of cooperative agreements between Government and industry to reduce greenhouse gas emissions. An additional 115 companies have forwarded Letters of Intent, and these are now developing their agreements. Agreements have been signed with organisations from the cement, aluminium, petroleum, mining, pulp and paper, energy generation and distribution (electricity and gas), manufacturing, commercial and transport industry sectors. In total, these represent more than 45% of Australia's industrial emissions. Sectoral strategies for the textiles, hospitals, hotels and metals industries have been launched to help medium-sized companies participate in the Program. Several more sectoral strategies are currently under development and will be launched progressively. Together, the companies involved project that they will reduce their forecast emissions by more than 21 Mt CO₂-e by 2000.
- Cogeneration provided 3.4% of Australia's electricity in 1994/95. Users included sugar mills, basic processing industries, chemicals and refining industries, and pulp and paper manufacturers. Measures are in place which, by the year 2000, are projected to result in a 250% increase in cogenerated electricity production compared with 1994/95 levels, significantly reducing CO₂ emissions.
- Renewable energy development receives support through research programs and funding support. Renewable energy technologies such as solar, photovoltaics, mini-hydro, biomass waste, and remote area power systems, are finding increasing applications.
- The Sydney Olympics in 2000 will be a showcase for new Australian energy technologies that can minimise greenhouse emissions. Facilities will combine best practice in environmental management, energy efficiency and sustainable development.

In the Transport Sector an agreement has been negotiated between the Commonwealth Government and the automotive industry to improve the fuel efficiency of new passenger vehicles through a

National Average Fuel Consumption target. The Government has also announced that it will be developing a new environmental strategy with the automotive industry. Alternative fuels are subject to a fuel excise exemption.

The Commonwealth Government has embarked on a major expansion of revegetation, plantation establishment and protection of existing vegetation, and is continuing the encouragement and promotion of sustainable land management practices. This effort is primarily focused through the \$1.25 billion Natural Heritage Trust (NHT).

- A major component of the NHT, Bushcare: the National Vegetation Initiative, aims to expand revegetation activities and reverse the long term decline in the quality and extent of Australia's native vegetation through joint work by Governments, industries and the community. The protection of native vegetation will also be pursued through the National System of Reserves and Regional Forest Agreements.
- Another key NHT program, the National Landcare Program, actively encourages the uptake of sustainable land management practices such as revegetation, conservation tillage and improved pasture management by Australia's farming community. These help reduce greenhouse gas emissions from the Agriculture Sector.
- The National Forest Policy Statement of 1992, the Farm Forestry Program, Plantations for Australia: the 2020 Vision, and the Wood and Paper Industry Strategy are initiatives that deliver greenhouse outcomes through sink enhancement.
- In addition, the Commonwealth Government is pursuing the reduction of vegetation clearance. This is an important environmental agenda in its own right, and is being addressed through the development of national vegetation management guidelines.

Initiatives by individual State, Territory and Local Governments to reduce greenhouse gas emissions form a substantial part of Australia's overall effort. Significant examples include:

- the establishment of the NSW Sustainable Energy Development Authority (SEDA) - which supports the development, commercialisation, promotion and use of sustainable energy technologies - as a key component of the NSW Government's reform of the electricity industry;
- the Victorian Government's Energy Smart Companies program, which has more than 300 companies as members, all committed to implementing energy management strategies within their business operations;
- the establishment of the joint UN/Commonwealth/Western Australian Government International Centre for the Application of Solar Energy, which promotes and facilitates the application of renewable (solar) technologies in developing countries;
- the use of alternative fuels in some classes of government vehicles. Several hundred buses fuelled by compressed natural gas are currently operating in NSW, South Australia, West Australia and the ACT; and
- Local Government action, primarily through the new Cities for Climate Protection - Australian campaign. This is based on the international model established under the International Council of Local Environment Initiatives. The campaign provides a formal framework and tools to help councils reach their reduction targets. Regulation by Local Governments affects sectors that together account for more than 50% of Australia's greenhouse emissions.

PROJECTIONS

The development of projections of greenhouse gas emissions is integral to policy formulation in relation to Australia's climate change strategic agenda. The process of compiling projections has included extensive consultation across Government, reports from consultants, and preliminary stakeholder involvement. The quantitative projections that have been produced include the effects of measures in place in mid 1997 to reduce emissions.



This is the first attempt at projecting emissions from all sectors of the Australian economy over an appreciable length of time; therefore, this is an early stage in the development of methodologies for emissions projections. Confidence in projections decreases as the time horizon extends, so the projections developed focus on 2010. Projections for later years should be interpreted as illustrative only.

Emissions from the Energy Sector (which includes Transport but excludes Fugitive Fuel emissions) accounted more than half of total emissions in 1990, and are expected to grow by 40% (106 Mt CO₂-e) from 1990 to 2010 as well as providing an increased share of total emissions. This projection reflects assumptions of continuing growth in GDP, in the resources sector, and in transport. It takes account of the main measures expected to reduce emissions – micro-economic reform in the Energy Sector and the Greenhouse Challenge Program. When combined with other measures, these are expected to reduce emissions in 2010 to 22 Mt CO₂-e below the level that they would otherwise have reached.

Emissions from the Agriculture Sector are projected to grow by 7% (6 Mt CO₂-e) from 1990 to 2010.

Plantation expansion and revegetation activities are projected to increase the sink in the Forestry Subsector by 8 Mt between 1990 and 2010.

Fugitive Fuel emissions, Waste emissions and non-energy emissions from Industrial Processes together accounted for about 10% of total national emissions in 1990, and are expected to fall slightly initially but then exceed their 1990 levels by 11% in 2010.

Because of the uncertainties at present in land clearing data and projection methods, projections of future emissions from this Subsector are not presented at this stage.

Excluding Land Use Change but including all other Sectors and sinks, Australia's total emissions are expected to increase by 28% (110 Mt) from 1990 to 2010. In the absence of measures that reduce emissions of greenhouse gases, Australia's emissions would have been approximately 552 Mt CO₂-e in 2010, a 43% growth from 1990 levels.

IMPACTS, VULNERABILITY AND ADAPATION

Australia recognises that climate change may have significant impacts on its natural environment, communities, industries, infrastructure and economy. As a result, the Commonwealth Government is supporting research to define the nature and likely extent of impacts, both positive and negative.

The latest climate change scenarios for Australia include temperature rises in the range 0.3–1.4°C by 2030 and 0.6–3.8°C by 2070, with the biggest increases occurring in the inland and the smallest in northern coastal regions. Winter rainfall is estimated to decrease over most of mainland Australia and increase over Tasmania. There is considerable uncertainty about how summer rainfall will change, with some models suggesting little change in the east and south-west and decreases over the rest of the country and others projecting general increases.

Climate change could have substantial effects on Australia's agricultural industries, with changes in the distribution of land suited to different enterprises and increases in production in some regions and reductions elsewhere. The climate change scenarios indicate that problems of land degradation are likely to increase in some areas. Adverse effects on Australia's biodiversity, with the potential to put some animal and plant species at risk, are also predicted. Coastal ecosystems, forests, infrastructure, human health, and the insurance and tourism industries are other areas where significant impacts could occur.

Australia recognises the importance of effective adaptation and the identification, development and implementation of strategies to help mitigate the potential adverse impacts of climate change and exploit potential benefits. Research projects are contributing to the development of approaches to adaptation, and some adaptation responses have already been initiated.

RESEARCH AND SYSTEMATIC OBSERVATION

Australia is one of only two southern hemisphere nations that are Annex I Parties to the Convention, and currently has the most comprehensive set of research and monitoring activities investigating climate change in the southern hemisphere.

Australia is an active participant in most of the major components of the International Geosphere-Biosphere Programme (including in the role of vice-chair) and the World Climate Research Programme, and has played a substantial role in the work of the IPCC. Australian scientists have made significant contributions to the understanding of climate processes, particularly the effects of naturally occurring aerosols on clouds and the role of oceans in climate change. Australia also conducts world class climate modelling and analysis research, and measurements and interpretations of greenhouse gases.

In addition, Australian scientists have been actively involved in a wide range of climate impact studies using scenarios based on Australian climate models. Areas of investigation have included agriculture, fisheries, hydrology and water resources, forests, natural ecosystems, coasts, human health and extreme weather.

Similarly, a wide range of studies have been undertaken on the effects of various response options. This work has included economic research to identify optimal international policies for responding to the climate change issue and relationships between international and national policy, and projections of future greenhouse gas emissions under different scenarios.

FINANCIAL ASSISTANCE AND TECHNOLOGY TRANSFER

As a Party to the Framework Convention on Climate Change, Australia is committed to assisting developing countries to meet their obligations under the Convention.

Development projects that directly contribute to greenhouse gas reduction supported by Australia through its overseas aid program in the 1995/96 financial year were valued at approximately A\$90 million. In addition, Australia committed A\$72.76 million to the Global Environment Facility (GEF) for the period 1991 to 1997.

As part of the Australian Activities Implemented Jointly (AIJ) initiative, Australian industry and Government are working closely to promote business sector linkages through workshops or sectorally focused emissions, and to generate mutually beneficial project proposals.

The Australian private sector is also involved in transferring environmentally sound technology to developing countries under commercial arrangements.

EDUCATION, TRAINING AND PUBLIC AWARENESS

Australia undertakes a broad range of community education and information projects as part of its national greenhouse response. All three spheres of Government, non-government agencies and industry are involved in their delivery. These projects aim to increase public awareness and knowledge of climate change and encourage individuals and organisations to contribute to the national response.

Activities undertaken have included the production of booklets, journals, books, World Wide Web sites, demonstration projects and training programs. For example, at a national level a number of Government departments have produced publications that are available to all Australians, while some local councils have undertaken local community campaigns to improve energy efficiency and recycling.

Energy efficiency has featured in many of the education campaigns. Power suppliers have provided energy saving information to customers, and many State and Territory Governments run award



schemes to acknowledge energy efficiency best practice and emission reduction programs undertaken by industry. A number of local councils have built demonstration projects as a way of educating their communities about energy efficiency and good urban design.

Furthering understanding of greenhouse through the formal education sector has been another feature of Australian activity. Programs and curricula within schools promote energy efficiency and recycling, and contain lessons about the science of climate change. The Commonwealth Scientific and Industry Research Organisation (CSIRO) is also vital in providing tertiary training in relation to the science of climate change.

SAFEGUARDING THE FUTURE: AUSTRALIA'S RESPONSE TO CLIMATE CHANGE

The Prime Minister announced a package of strengthened greenhouse measures on 20 November 1997. The \$180 million five year package includes completely new measures and also the substantial expansion of existing programs. It will take Australia to world best practice and enhance the nation's competitive strengths.

The description of policies and measures and the projections in this publication do not incorporate the measures in this statement by the Prime Minister. The new package will reduce Australia's net emissions growth from 28% to 18% (excluding land use change) or some 39 Mt of emissions by 2010 (from 494 Mt to 455 Mt).

THE MAJOR INITIATIVES INCLUDE:

- Boosting the use of **renewable energy**. The Government will work with the States to set a mandatory target for electricity retailers to source an additional 2% of their electricity from renewable energy sources by 2010. To support the further uptake of renewable energy, \$60 million will be provided for the commercialisation of renewable energy technologies.
- Establishing a **Commonwealth Greenhouse Office** within the Department of the Environment. This Office will be responsible for delivery of Commonwealth greenhouse programs, and will provide a central point of contact for industry and other stakeholder groups. The Office reflects the priority that the government is giving domestic greenhouse action. It will drive Commonwealth greenhouse policies and programs including those previously delivered by the Departments of Primary Industries and Energy and Industry, Science and Tourism.
- Accelerating **energy market reform**. Efficiency standards for fossil fuel electricity generation will be implemented by 2000, ensuring Australia adopts best practice. Accelerated energy market reform will deliver both economic and environmental, particularly greenhouse benefits.
- Improving the **fuel efficiency** of our car fleet. The Government will negotiate with the automotive industry to secure a 15% fuel efficiency improvement target by 2010 over business as usual. There will be mandatory, model specific, fuel efficiency labelling
- Implementing national energy efficiency **codes and standards** for buildings, appliances and industrial equipment. Energy efficiency codes and standards will be developed that will take us to best practice standards in these important areas.
- Fostering growth in **plantation forestry and native revegetation** to act as a sink for greenhouse gas. The Government will work to remove impediments to the development of commercial plantations to facilitate the Plantations 2020 vision of trebling the plantation estate by 2020. This will complement the Bush for Greenhouse programme which will forge partnerships between the corporate sector and landholders through the corporate funding of revegetation projects.

- Extending the successful voluntary industry **Greenhouse Challenge Program** to allow even greater uptake by industry. More than 1000 large and medium companies will participate by 2005. An innovative Greenhouse Allies program for smaller businesses is to be included in the Challenge.
- Supporting the extensive uptake of the worldwide **Cities for Climate Protection** campaign by Australian Local Governments. Through the campaign Local Governments will work with their communities to reduce emissions through increasing energy efficiency, and developing creative transportation, waste management and building policies.





Australia in context

INTRODUCTION

The Framework Convention on Climate Change (FCCC) 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 country's climate, geography, demographic trends, natural resource base, political and institutional structure, economic composition, trading relationships, energy production and consumption profile, and a range of other individual factors, are important in understanding the opportunities and constraints that it faces in engaging in emission mitigation and sink augmentation activity. Identifying a country's environmental and economic vulnerability to the effects of climate change also requires a thorough examination of all these factors.

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

GEOGRAPHY

Australia has a land area of 7 682 300 square kilometres, excluding external Territories, making it the sixth largest country in the world and the largest in the southern hemisphere. 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 some 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 stretches for 36 700 kilometres, providing a diverse marine environment including tropical mangrove and coral reef habitats. Being surrounded by oceans also has a major influence on the continental climate.

Australia has been geographically isolated from other continents since it separated from Antarctica 35 million years ago. As a result, a unique biota has evolved. Australia is recognised as one of about a dozen countries with megadiversity. Australia 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 as a result tend to be shallow and infertile.

These factors combine to give Australia a distinctive physical geography and a unique natural environment, and contribute to its vulnerability to climate change impacts.

Figure 2.1 Map of Australia showing States and Territories

National parks and world heritage areas

Natural environment conservation is a vital issue for Australia's well-being. Australia places importance on developing and maintaining a diverse system of nature conservation areas. The Government is acutely aware of the potential threat of climate change to these natural ecosystems.

In June 1996, Australia had 3983 terrestrial parks and reserves (totalling nearly 60 million hectares) and more than one hundred marine and estuarine protected areas (totalling nearly 40 million hectares). The vulnerability of these areas to potential climate change impacts is described in Chapter 6.

CLIMATE

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

As the driest of all inhabited continents, more than three-quarters of Australia has a median rainfall of less than 600 millimetres annually and about half the country receives less than 300 millimetres. Figure 2.2 shows the annual median rainfall distribution.

Figure 2.2 Annual median rainfall distribution (in millimetres)

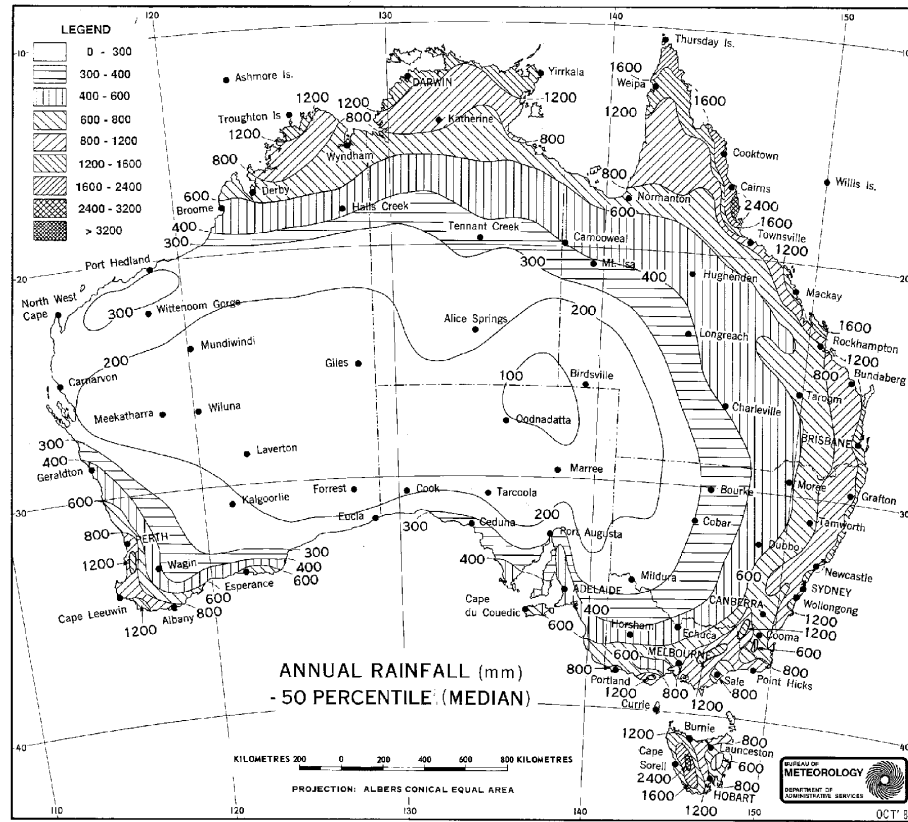
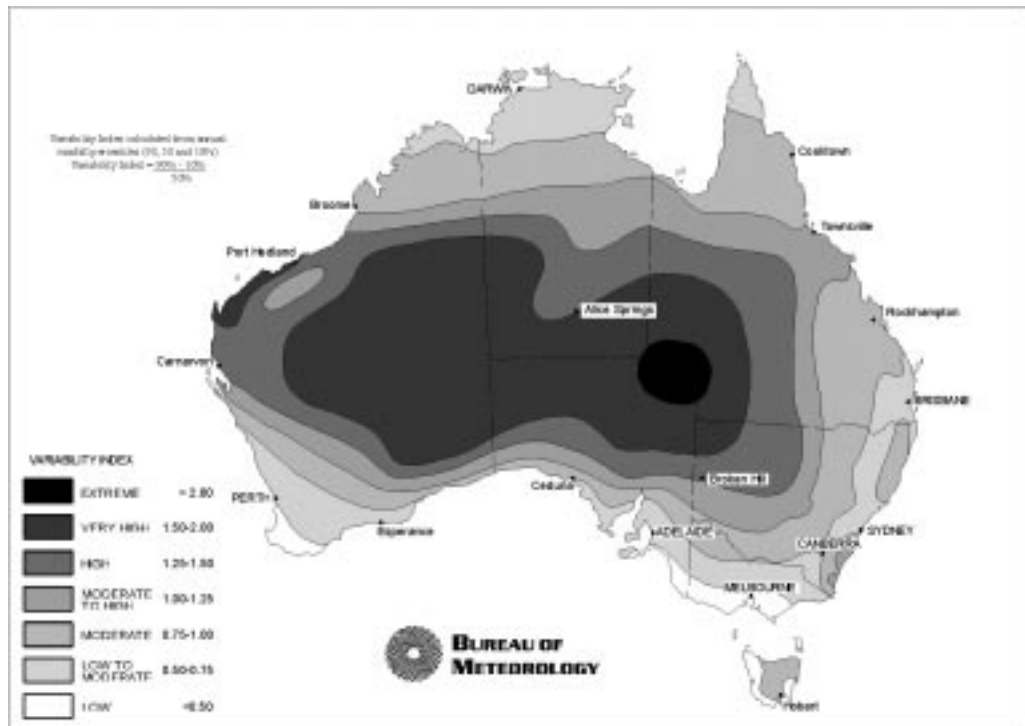


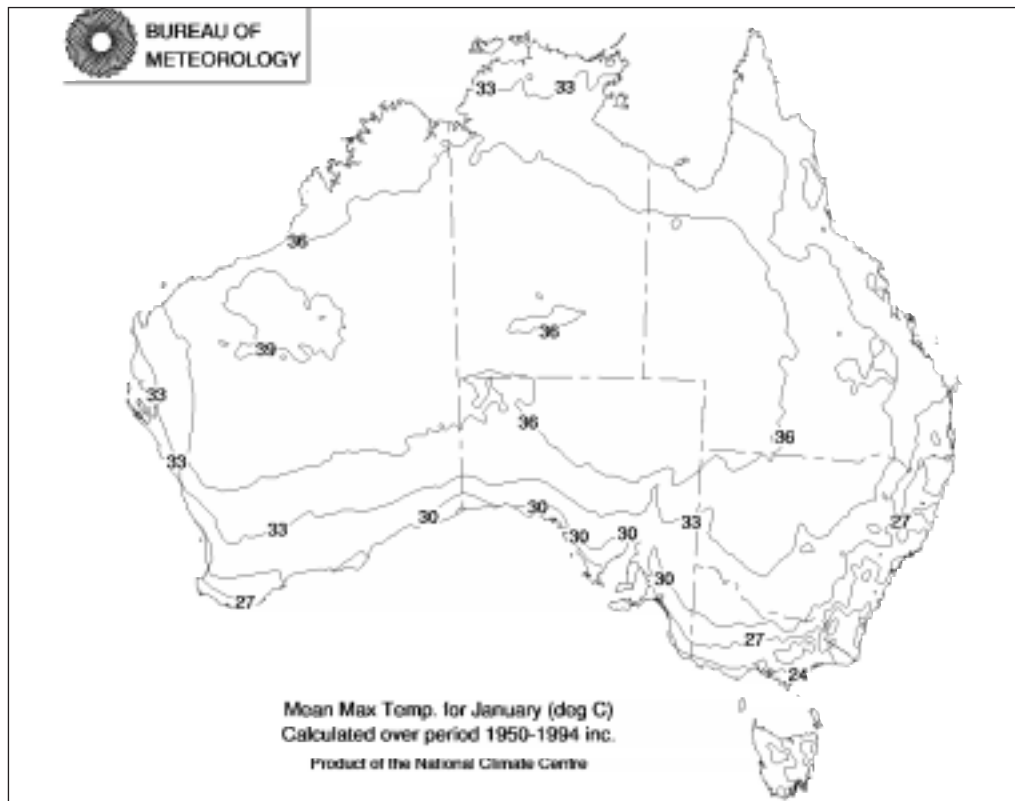
Figure 2.3 Annual rainfall variability



The most notable feature of the climate is the extreme rainfall variability, which affects much of the continent and is illustrated in Figure 2.3. 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 interannual rainfall variability. It has a cycle that varies between two and eight years, which exposes Australia to relatively frequent floods and droughts and also results in the strong variability in frequency of such extreme events 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 2.4.

Figure 2.4 Average daily maximum temperatures across Australia for January



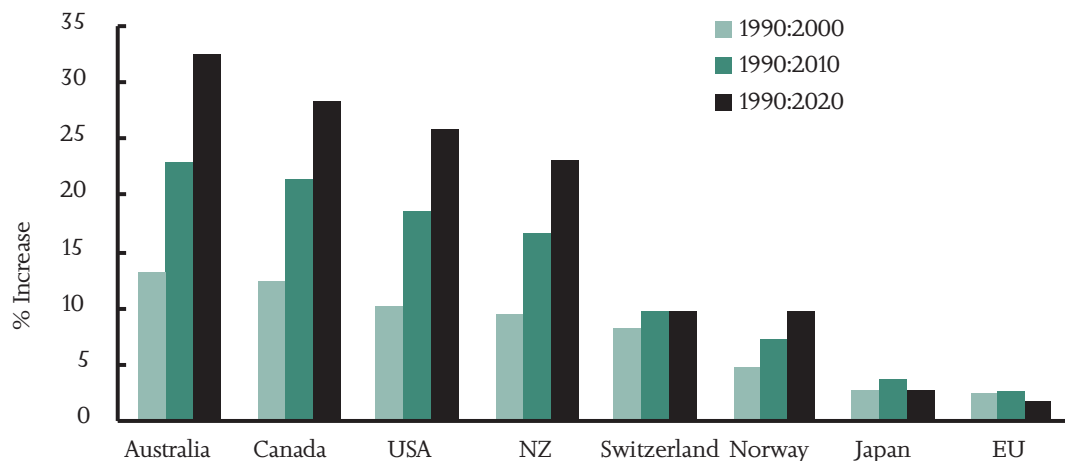
Along the narrow coastal strip, where the majority of the population centres are located, sea breezes moderate maximum temperatures during warmer months. The coastal regions also experience smaller daily temperature ranges than inland areas because of the influence of the sea. Frosts are a regular occurrence 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 year to year, and is usually restricted to south-eastern Australia in areas above about 1500 metres. It rarely occurs below 500 metres. High levels of solar radiation are a feature of most of the continent. There are also areas of high winds suitable for harnessing for wind power generation.

POPULATION

Demographic factors are of key importance in determining a country's vulnerability to climate change and its ability to mitigate, and adapt to, the effects of climate change.

While Australia's population is relatively small – 18.4 million in 1996 – 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 67%. By contrast, the population of the European Union member states increased by only 15.8%. These differences are related mainly to features of immigration intake and the age structures of countries. As shown in Figure 2.5, projections for 1990 to 2020 show a similar trend, with Australia's population growing by 29.6% compared with growth in the European Union of 1.7%. The projected increase in Australia's population can be expected to exert increasing pressure on resources and energy use well into the next century.

Figure 2.5 Projected developed countries' population increases



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 in 1996/97 of A\$510 billion (or around US\$400 billion).

Australia is in many respects unique among Annex I Parties, in that:

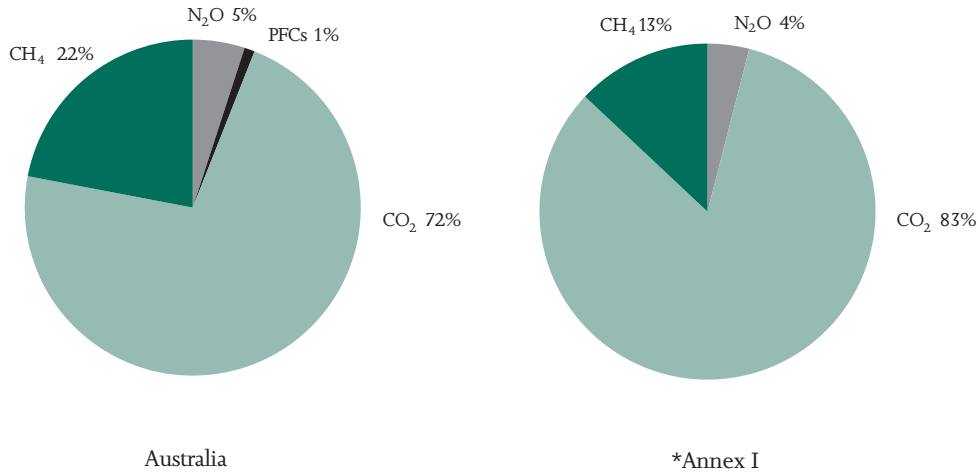
- it has a rapidly increasing population;
- vast distances separate urban centres within Australia, and even greater distances separate Australia from other countries;
- unlike most other Annex I countries, which tend to have relatively stable patterns of land usage, land use patterns in Australia are still undergoing significant change; and
- production and exports of fossil fuels and mineral products play a significant role in the economy.

Australia's emissions profile is atypical among Annex I Parties. As shown in Figure 2.6, while the energy sector was the largest source of emissions it accounted for only around 58% of Australia's emissions in 1990 compared with an average of 87% for Annex I countries. Agriculture was a significantly more important emission source for Australia than for other countries, with much of

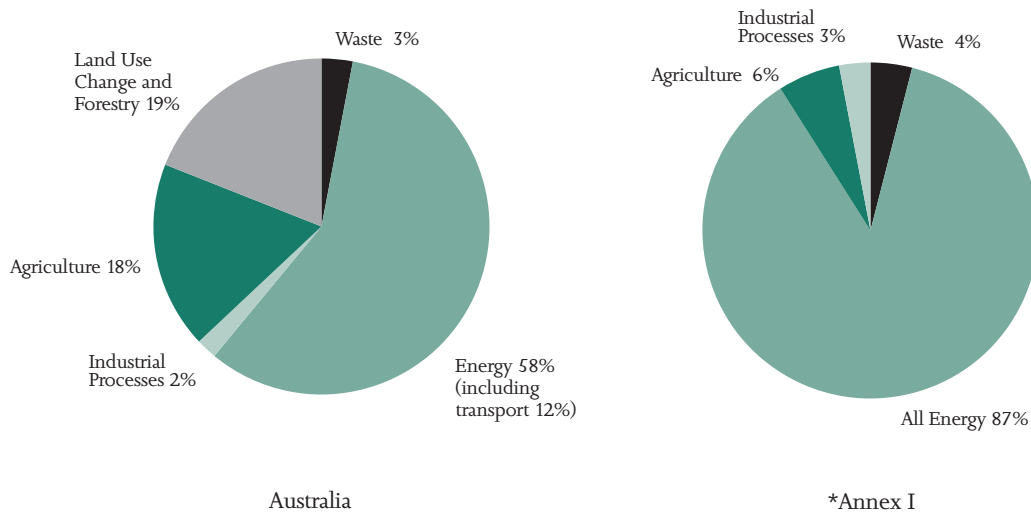
Australia's agricultural produce being exported. In Australia, the land use change and forestry sector is a net source of emissions rather than a net sink; this is the case for only one other Annex I country. Australia's emissions profile by gas is also very different from that of other OECD countries, with methane forming a significant portion of emissions.

Figure 2.6

(a) 1990 emissions by gas: Annex I and Australia



(b) 1990 emissions by sector: Annex I and Australia



* Annex I charts cannot include the Land Use Change and Forestry Sector which, as a sink, is a negative amount.

Sources: FCCC Secretariat Home Page, 1990 data tables, and National Greenhouse Gas Inventory 1990.

Australia's export links with developing countries in the Asia-Pacific region

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 fast-growing economies of the Asia-Pacific region and the complementarity between the energy-intensive nature of the region's imports. Australia's exports have been growing by around 7–8% per annum, and those to East Asia at an even faster rate.

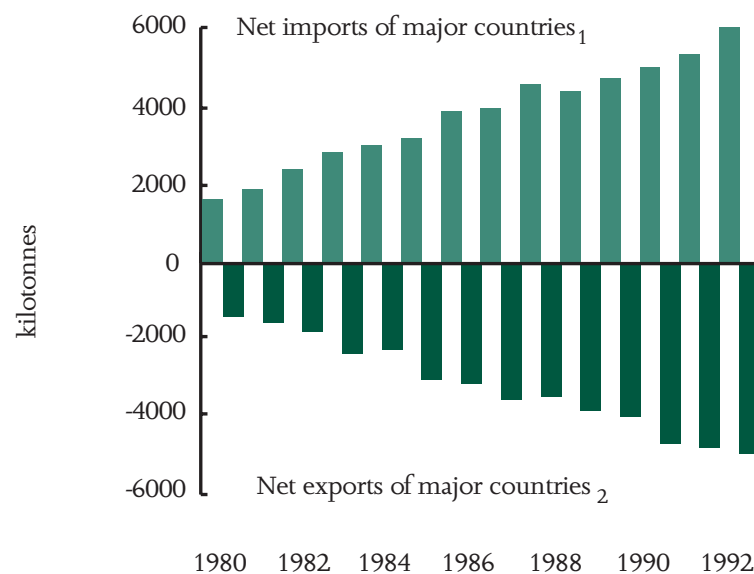
No other OECD country has this combination of a concentration of emission-intensive goods in its exports with the dominance of the fast-growing regions of Asia in its direction of exports. Furthermore, trade liberalisation through the Uruguay Round and through regional organisations such as Asia-Pacific Economic Cooperation (APEC) is likely to further increase Australia's production of energy- and greenhouse gas-intensive activities to service growing Asia-Pacific markets.

Australia's continuing specialisation in energy-intensive industries

All the major industrialised economies have seen a decline in the importance of their goods-producing sector relative to their service sector over the past few decades. This has also been Australia's experience. However, in contrast to other OECD countries, the impact of the shift towards the service sector has been significantly offset by a shift towards energy- and greenhouse-intensive production. The net effect of the structural change towards both energy-intensive and service industries has been to increase the energy intensity of the Australian economy between 1974 and 1995 by about 10%.

Australia's exports are relatively energy- and greenhouse-gas-intensive; petroleum products, basic metals, minerals and resources, agriculture and food products, meat and milk products and chemicals together accounted for 85% of Australian exports in 1990. Australian imports – such as machinery and miscellaneous manufacturing, transport equipment, textiles, clothing and footwear, alcohol, paper and wood products are generally less energy-intensive. These industries together accounted for 71% of Australian imports in 1990.

Figure 2.7 Structural change in the aluminium industry: changing trade flows for major countries



1. Countries include EU-12, Sweden, Austria, Japan, United States.

2. Countries include Australia, Canada, Norway, Venezuela, Indonesia.

The importance of changing trade patterns and specialisation by countries is best illustrated through the experience of the aluminium industry, which is among the most energy-intensive of industries. For some time aluminium producers have chosen to locate new production facilities in countries with low cost energy, and have placed less emphasis on being close to final markets. In some cases, such as Japan in the early 1980s, production facilities have been closed down and replaced offshore in countries such as Australia and Canada. The global specialisation of the industry has led to a number of exporters emerging, where the major proportion of production is destined for foreign markets. As shown in Figure 2.7, the growth in exports from this small band of countries mirrors the growth in imports of the major markets.

LAND AND MINERAL RESOURCES

Australia's diverse climate zones, topography and soils, and mineral resources support a wide range of land uses, which have resulted in a unique emissions profile. This provides Australia with particular opportunities and challenges in developing its response to climate change.

Agriculture

Agriculture has traditionally been a significant component of the Australian economy. It currently accounts for around 4% of GDP, but is more important in trade terms, accounting for nearly 30% of total Australian merchandise exports. Agricultural exports were worth more than \$23 billion in 1996/97. Australia's agricultural trade is also very significant by world standards. Australia is the world's largest exporter of wool, the second largest exporter of meat and sugar, and a significant exporter of cotton (third largest), wheat (fourth largest), barley (fifth largest), and rice (eleventh largest).

Agricultural and pastoral properties in Australia 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. Although only 10% of the Australian continent is arable, many different types of farming practice have been introduced to accommodate the wide range of physical conditions such as climate and soil type.

With Australia being a major agricultural exporter, it is arable, many different types of farming practice have been introduced as an important component of Australia's emissions profile, accounting for about 18% of emissions in 1990 as presented in Figure 2.6. Agricultural emissions are a relatively more important source of emissions for Australia than for most other OECD countries.

This agricultural profile provides Australia with risks and opportunities unique within the developed world. The potential impacts of climate change may have serious implications for Australia's agricultural sector; these potential vulnerabilities are considered in Chapter 6.

However, improved practices in agriculture can play an important role in reducing greenhouse gas emissions while, at the same time, contributing to sustainable development objectives such as avoiding biodiversity loss, preventing land degradation and improving soil and water conservation.

Cognisant of these opportunities, Australia's approach to addressing global warming is rooted firmly in the comprehensive approach. It addresses all greenhouse gases, sources, sinks and sectors, fully utilising the significant 'no-regrets' opportunities available to enhance the sustainability of agricultural practices while at the same time significantly reducing greenhouse emissions from the agricultural sector.

LAND USE CHANGE

The main source of emissions within the land use change and forestry sector is land use change for agriculture. In 1990 more than 650 000 hectares were cleared, resulting in about 122 Mt of emissions.

A surge of land clearing took place in Australia from the mid 1960s to the mid 1970s. Since then land clearing has generally declined, but it is still occurring nationally at a rate of up to half a million hectares per year. Statutory or regulatory controls over the clearing of native vegetation have been introduced in some States. Availability of land suitable for clearing for agricultural purposes on a commercially viable basis is declining. There is also a growing realisation of the necessity for, and support for, agricultural practices that are ecologically sustainable. It is expected that, in the future, land clearing will be increasingly used for maintenance of land previously cleared to remove regrowth of woody and other vegetation. These factors suggest that clearing of intact native vegetation should decline further, with a consequent reduction in emissions from such activities.

Forestry

Managed forests in Australia are a net sink for carbon dioxide, sequestering about 22 Mt in 1995.

Australia has about 156 million hectares of native forest and woodland, covering about 20% of the continent. The eucalypts that dominate much of this area consist of more than 700 species, providing a rich diversity of ecosystems and supporting a wide and complex variety of fauna.

There are just over one million hectares of commercial forests in Australia, consisting mainly of large units of industrial eucalypt and pine plantations. These forests also are a net sink for carbon dioxide. With the planned expansion of commercial plantations over the next 25 years, this sink is expected to increase.

Commercial farm forestry (or non-industrial plantations) is another small but increasingly important component, and is not represented in the above figures. Revegetation activities on agricultural lands also contribute to overall sink activity.

Mineral resources

Mineral resources and resource processing industries generate more than 8.5% of Australia's GDP and more than 400 000 jobs (around 5% of employment). Mineral resource commodities, worth about \$35 billion in 1996/97, account for 44% of Australian merchandise exports.

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.

ENERGY

The energy sector includes: the exploration for, and recovery of, natural gas and crude oil; 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 consumption of electricity.

Production

Australia is far more dependent on fossil fuels than any other OECD country. For example, Australia's reliance on coal, which produces more CO₂ emissions per unit of energy generated than any other fossil fuel, is double the OECD average. Similarly, fossil fuels account for nearly 94% of Australia's



energy inputs – a far greater reliance on fossil fuels than for any other OECD country.

Australia's near-exclusive reliance on fossil fuels is primarily due to the abundance of low cost fossil fuels, limited and close to fully utilised hydro resources, and public and environmental concerns preventing the use of nuclear energy (which provides around 11% of the OECD's energy and around 25% of electricity production).

Investment in coal-fired power stations reached a peak in the 1980s, leading to a surplus of capacity in the populous eastern States. This over-capacity is likely to prevail until around 2000. Reforms to Australia's gas and electricity markets currently being implemented suggest that additions to capacity in the future will be increasingly in the form of cogeneration, gas and renewables.

Ongoing energy market reform has reduced some barriers to the penetration of new energy supply technologies, especially in electricity generation. In the medium term, greater penetration of natural gas offers a significant opportunity to reduce the greenhouse intensity of energy supply in a cost competitive way, based on Australia's abundant supplies of natural gas. Gas is projected to account for 21% of fuel inputs for thermal electricity generation in 2010, compared with 9% in 1995/96. Use of cogeneration technologies, where waste heat from industrial processes is converted to electricity, is expected to quadruple by the year 2010.

Demand

Australian demand for electricity grew at an average annual rate of 5.7% between 1982/83 and 1989/90. Nearly one-third of the absolute growth in demand came from the aluminium industry, for which electricity demand grew at an average rate of 13% per annum. Demand excluding the aluminium industry grew at 4.4% over this period. Total electricity consumption slowed markedly during 1990/91 and 1991/92 – in both the industrial sector, as a result of slowdowns in industrial activity and the residential sector due to relatively mild weather conditions and depressed real income growth. Since then, growth has rebounded underpinned by an upturn in economic activity and renewed growth in residential demand.

A number of studies of the Australian energy services sector have concluded that there is some scope to reduce energy use cost-effectively, through energy efficiency and switching to less greenhouse-intensive energy sources.

Renewables

Renewable energy, mostly hydro, accounts for around 6% of Australia's energy input, an amount broadly comparable with the OECD average of 6.4%. Renewable energy is consumed to some extent in all States, but the types vary widely depending on the available resources. For example, hydro-electricity accounts for nearly all of Tasmania's power generation capacity, but is much less important in other States. In Queensland, nearly 11% of energy is from renewable sources – particularly in the form of bagasse, which is used in the sugar refining industry. Other forms of renewable energy – solar for domestic and commercial uses, other biomass fuels, and renewable gas from landfill and sewerage – account for small levels of energy consumption in each state.

Australia has the potential over time to make greater use of some forms of renewable energy, although there is little further potential for hydro. Australia has a world-class research base with demonstrated achievement, especially in areas such as solar thermal, photovoltaics and biomass. Renewable energy technologies and manufacturing in Australia are well positioned to take advantage of export markets, particularly in developing countries that have growing energy demands and will be looking to procure energy technologies suited to their needs.

Exports

In contrast to most other OECD countries, Australia is a significant net energy exporter. For example, in 1995/96 nearly 70% of Australia's total energy production was destined for overseas markets (valued at around \$A14 billion or 18% of Australia's export earnings). Australia's major exports are black coal and uranium, with 53% and 33% shares of total energy exports (in petajoules) respectively. In terms of global energy trade, Australia is the world's largest coal exporter and second largest uranium exporter.

Australia has also recently been a major exporter of liquefied natural gas (LNG), with strong future growth expected. Production is emission-intensive and leads to significant greenhouse emissions in Australia. However, natural gas produces only about half of the greenhouse emissions associated with other fossil fuels, which are already a large part of the energy mix in the Asian region. Australian LNG exports can thus assist developing countries to ameliorate their expanding greenhouse emissions.

TRANSPORT

Total emissions from the transport sector comprised 12% of Australia's total net greenhouse gas emissions in 1990, and almost 21% of energy sector emissions.

Passenger transport

Australia's urban transportation needs are greater than those in many other developed countries due to urban population densities and patterns of land use that result in significant distances between homes, between the home and the workplace, and between the home and recreational facilities.

The decentralised land use patterns of Australian cities also require greater intra-city travel and reliance on car use. In 1992/93, the car accounted for about 87% of passenger-kilometres, while the public transport share was less than 8% (bus 3%, rail 4.6% and ferry 0.2%).

While the car is less dominant in non-urban passenger transport, it accounts overall for more than 60% of passenger-kilometres. Air transport accounts for 19% of the market, buses 11% and light commercial vehicles 5.5%.

Domestic freight transport

Due to Australia's geographic size, the population dispersal within and between urban centres, the distances between natural resources and manufacturing and market centres, and the distances between Australia and its trading partners, 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 Australia's total domestic freight task in terms of tonne-kilometres (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 freighters, and of primary products from inland mines and farms to coastal city markets and export ports by railway. The total domestic freight task was about 2289 billion tonne-kilometres for 1992/93, of which 67% was due to bulk commodities.



CONSTITUTIONAL ARRANGEMENTS

The Commonwealth of Australia consists of a federation of eight self-governing States and Territories: Victoria, New South Wales, Queensland, Western Australia, South Australia, Tasmania, the Australian Capital Territory and the Northern Territory. Each of the States and Territories has its own Government. In addition, there are currently 707 Local Governments in Australia.

The 1901 Australian Constitution provides for the operation of the Federal Parliament. The Commonwealth Government is headed by the Prime Minister and includes Ministers who are responsible for particular federal matters.

The complexity of Australia's constitutional arrangements has implications for greenhouse response action. While the Commonwealth can provide leadership and take part in international negotiations, State and Local Governments have responsibility in many areas related to the implementation of climate change policy. All three spheres of government have endorsed Australia's National Greenhouse Strategy, giving Australia a national approach to the challenge of anthropogenic climate change.

National Greenhouse Gas Inventory

INTRODUCTION

Development and compilation of the National Greenhouse Gas Inventory is one of the priority elements of the National Greenhouse Strategy.

The Inventory provides a foundation for the development of climate change policy and a key means of appraising progress in implementing greenhouse response measures. It underpins the derivation of performance indicators for the National Greenhouse Strategy and projections of future patterns of emissions.

Australia has a distinctive profile of greenhouse gas emissions when compared with the emissions patterns of other Annex I countries:

- Energy Sector emissions are prominent though proportionally less than in many other OECD countries, but with strong growth evident; and
- emissions and sinks associated with agriculture, land management and forestry constitute significant components of the overall inventory.

Carbon dioxide emissions from the clearing of native vegetation for animal and crop production are significant. Revegetation is developing into an increasingly significant sink for removal of CO₂ from the atmosphere.

When viewed in terms of gas-by-gas composition, the emissions profile shows that carbon dioxide dominates (72% in 1995), but accounts for a lesser proportion than is typical for OECD countries. Methane features more strongly (23% in 1995) when compared with most OECD countries, mostly as a result of cattle and sheep production serving export markets.

DEVELOPMENT OF THE GREENHOUSE GAS INVENTORY

Australia has made, and will continue to make, a significant contribution to the IPCC in developing methodology to assist countries in preparing standardised inventories of greenhouse gases. For example, in September 1997 Australia hosted an IPCC technical workshop on methodology relating to biomass burning and land use change and forestry.

Australia's Greenhouse Gas Inventory is compiled annually, reflecting international and national commitments.

The first national Inventory, for the year 1990, was prepared in 1994 and presented in Australia's first National Communication under the Climate Change Convention. The most recent annual Inventory covers the year 1995¹, and has been lodged with the Secretariat to the Climate Change Convention. This second National Communication provides a summary of the Inventory results for the period 1990 to 1995. (The Inventory for 1996 is in preparation.)

¹ The Inventory year 1995 refers to the period 1 July 1994 to 30 June 1995, and similarly for other years.

In light of the federal governmental structure in Australia, inventories broken down to the level of emissions from each State and Territory are produced periodically. Such sub-inventories for 1995 are being prepared (and the 1990 inventories recalculated). These State inventories support the development of climate change policy and response measures on a regional basis.

Methodologies and data

The IPCC methodology designed for international application provides the basis for the preparation of Australia's Greenhouse Gas Inventory.

In light of the key position of the Greenhouse Gas Inventory in the overall National Greenhouse Strategy, Australia has invested significant resources in developing more advanced inventory methodologies, which build upon, and are fully consistent with, the IPCC approach. Similarly, significant effort is being made in improving activity data required to generate quality inventory output.

Preparation of the National Greenhouse Gas Inventory is facilitated through an intergovernmental inventory committee.

A particularly important role is played by national expert groups, which are responsible for advancing methodology and data gathering at the sectoral level. Proposals for methodology are carefully reviewed by a wide circle of professional experts in research institutions, government and industry, and by community interests. Increasingly, companies and industry sectors are contributing to the advancement of inventory methodologies and data gathering, particularly through the Greenhouse Challenge program of cooperative agreements. The petroleum exploration industry is one such recent example.

Research activity is undertaken to support the development of inventory methodology and data gathering. In the period since Australia's first National Communication in 1994, the methodology in each sector of the Inventory has undergone substantial re-examination and development. This review has taken into account the intervening development in IPCC methodology endorsed by the Conference of Parties to the FCCC.

The most up-to-date methodologies have been published as a set of revised workbooks - in 1996 for most sectors and in 1997 for CO₂ from the Land Use Change and Forestry Sector. In turn, Australia has made inputs to the IPCC inventory process, building on this experience with national methodology. Full bibliographic details of Australia's published inventories and methodologies are provided at the end of this chapter.

A fundamental principle of Australia's Greenhouse Gas Inventory is the transparent presentation of data and methods. In this connection, a major goal is the improvement of methodology and data. The endeavour to improve methods is carefully focused on the areas of greatest uncertainty and significance. Against these criteria, a strong effort is being focused on the Land Use Change and Forestry Sector.

Significant advances have been made since Australia's first National Communication, but important uncertainties still remain in the input data and methodologies. More importantly, Australia is confident that even more significant progress will be made over the next few years. This developmental agenda is likely to have wider benefits for the IPCC methodology, and most particularly for developing countries that share with Australia a stage of transformation in land use patterns.

OVERVIEW OF NATIONAL EMISSIONS

Emission estimates associated with land clearing are highly uncertain. For this reason, Australia's most recent National Greenhouse Gas Inventory (covering 1995) reports emissions associated with land clearing separately from the total greenhouse gas emissions. This document also follows this change in approach from previous practice in reporting inventory data.

The national greenhouse gas emissions total is therefore made up of emissions from the following sectors and subsectors: the Energy (including Combustion, Transport and Fugitive), Industrial Processes, Agriculture and Waste Sectors, and the Forestry and Other (pasture improvement) Subsectors of the Land Use Change and Forestry Sector (excluding the Forest and Grassland Conversion Subsector).

Australia's greenhouse gas emissions, excluding land clearing², were the equivalent of 380 Mt of carbon dioxide in 1990 and 403 Mt in 1995, an increase of about 6%.

Between 1990 and 1995 all sectors were net emitters, except for the Forestry and Other³ Subsector (which is a Subsector of the Land Use Change and Forestry Sector). In this Subsector removals exceeded emissions in every year from 1990 to 1995. Table 3.1 summarises emissions and changes since 1990. Greater detail of subsectors is given in Table 3.10.

Table 3.1 Net greenhouse gas emissions by sector, 1990 to 1995 (Mt CO₂-e), excluding land clearing

Sector	1990 Mt CO ₂ -e	1991 Mt CO ₂ -e	1992 Mt CO ₂ -e	1993 Mt CO ₂ -e	1994 Mt CO ₂ -e	1995 Mt CO ₂ -e	Mt CO ₂ -e % Change 1990-1995	% Change 1990-1995
1 All Energy	293.3	295.5	299.6	301.9	305.6	317.4	24.1	8.2
Stationary Energy	205.5	208.4	209.5	212.0	213.9	223.0	17.5	8.5
Transport	61.8	61.3	63.2	64.2	66.0	68.8	7.0	11.3
Fugitive	26.0	25.8	26.9	25.7	25.7	25.6	-0.4	-1.5
2 Industrial Processes	12.1	11.7	10.4	10.2	9.9	9.0	-3.1	-25.6
3 Solvent & Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA
4 Agriculture	88.8	89.0	87.1	87.3	86.9	87.4	-1.4	-1.6
5 Land Use Change and Forestry (a)	-29.4	-30.5	-31.9	-31.2	-29.7	-27.6	1.8	-6.1
6 Waste	14.8	15.1	15.4	15.8	16.1	16.4	1.6	10.8
Total of above	379.6	380.8	380.6	384.0	388.9	402.6	23.0	6.0

Percentages may not add due to rounding. (a) Excludes emissions from Forest & Grassland Conversion Subsector.

Changes in emissions since 1990

The largest percentage increases in emissions were in the Transport (11%), Waste (almost 11%) and Stationary Energy (9%) Sectors. Because of its dominance in the Inventory, Stationary Energy represented the strongest factor in overall emissions trends.

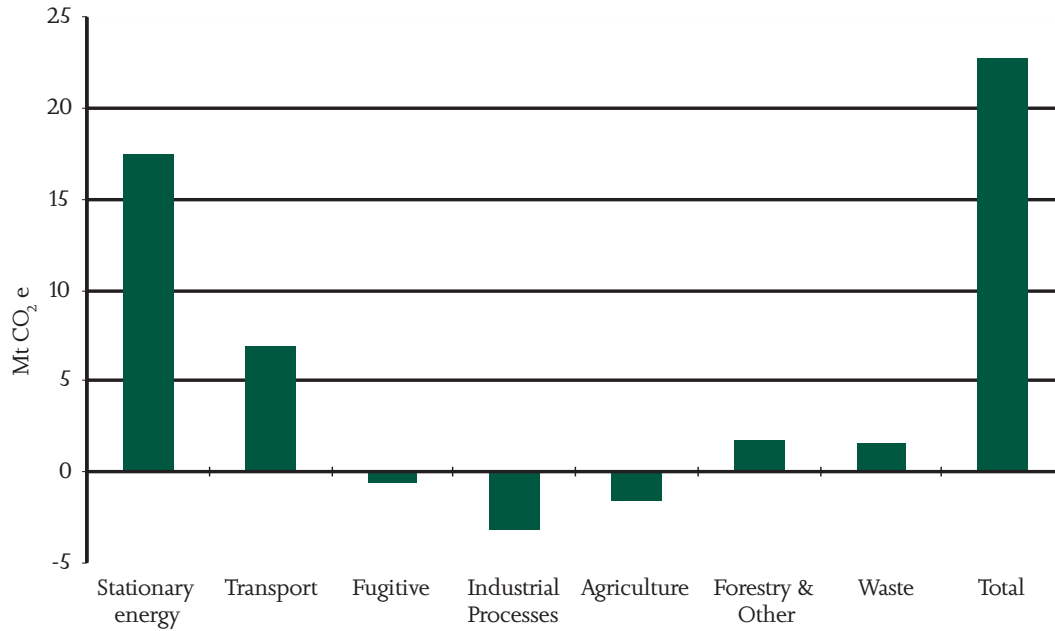
Emissions from Industrial Processes decreased by almost 26%, emissions from Agriculture by almost 2%, and Fugitive Fuel emissions by about 2% (see Table 3.1 and Figure 3.1). Forestry and Other was a carbon sink in each year, but net CO₂ removal decreased by 6% between 1990 and 1995. This is because emissions due to timber harvesting have increased at a greater rate than carbon is sequestered in incremental growth.

² Land clearing is equivalent to the IPCC Land Use Change and Forestry Sub-Category Forest and Grassland Conversion (5B)

³ Forestry and Other is equivalent to Subsector 5A (Changes in Forest and Other Biomass Stocks) and Subsector 5D (Other: pasture improvement and emissions from wildfires and prescribed burning).



Figure 3.1 Change in greenhouse gas emissions and removals by sector, from 1990 to 1995 (Mt CO₂-e), excluding land clearing



EMISSIONS BY GREENHOUSE GAS TYPE (EXCLUDING LAND CLEARING)

Carbon dioxide makes the largest contribution to the inventory of Australia's emissions, accounting for almost 67% of all emissions in 1995 excluding those from land clearing almost 64% in 1990 (see Table 3.2).

Methane accounted for 27% of all emissions in 1995 in CO₂-e terms, slightly less than its share in 1990.

The nitrous oxide share was about 6% in 1995, virtually unchanged from 1990.

Emissions of perfluorocarbons (PFCs) declined by more than 70% between 1990 and 1995. A detailed breakdown of the contributions of the direct greenhouse gases for each subsector for 1995 is provided in Table 3.10.

Figure 3.2 Share of emissions by greenhouse gas, 1995 (Mt CO₂-e), excluding land clearing

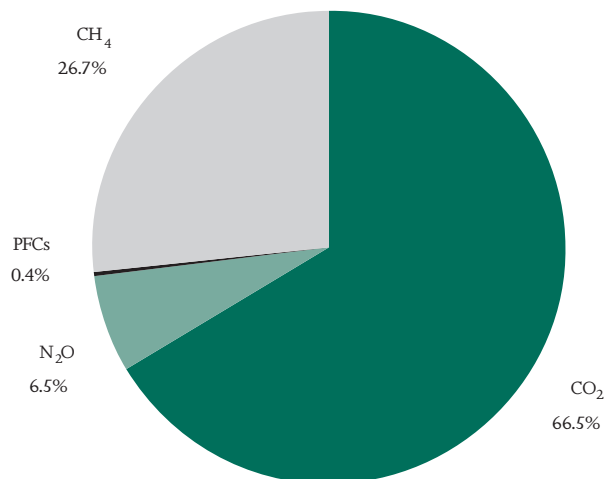


Table 3.2 Net greenhouse gas emissions and changes by gas, 1990 and 1995 (Mt CO₂-e), excluding land clearing

	1990 Mt CO ₂ -e	1995 Mt CO ₂ -e	Mt CO ₂ -e Change	% Change
CO ₂	242.0	267.7	25.7	10.6
CH ₄	108.3	107.4	-0.9	-0.8
N ₂ O	24.4	26.1	1.7	6.4
PFCs	4.9	1.4	-3.4	-70.5
Total	379.6	402.6	22.8	6.0

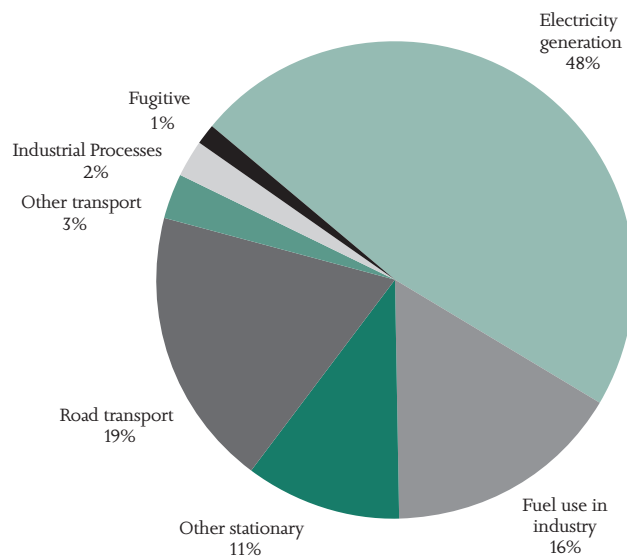
Excludes Forest & Grassland Conversion Subsector.

Carbon dioxide

The great majority of CO₂ emissions in Australia come from the combustion of fossil fuels. CO₂ emissions from energy related sources shown in Figure 3.3 totalled 290 Mt in 1995. Stationary energy use accounted for more than 76% of the total and transport for around 22%.

The largest single contributor to CO₂ emissions was electricity generation (which relies mainly on coal), followed by road transport. Other energy use sources include fuel use in the residential and commercial sectors and petroleum use by equipment in agriculture, forestry and fishing, and fugitive fuel emissions.

Figure 3.3 Share of CO₂ emissions by sector, 1995, excluding land clearing



Emissions of CO₂ were offset partially by the uptake of carbon through the growth of forests and other woody biomass, and through pasture improvement. These sinks accounted for the equivalent of around 29 Mt CO₂ in 1995, resulting in a net CO₂ emissions total of 268 Mt (see Table 3.3). Managed forests, a net sink of 21 Mt, comprises 59 Mt of emissions resulting from the harvesting of timber and an 80 Mt sink due to annual growth of the forest.

CO₂ emissions from electricity generation, fuel combustion activities, transport and fugitive fuels were almost 11% higher in 1995 than in 1990. In addition, forests and other woody biomass did not sequester as much carbon in 1995 as in 1990, diminishing their offsetting effect. As a result, the overall increase in net emissions of CO₂ from 1990 to 1995 was somewhat higher, almost 11%.

Emissions from electricity generation were almost 10% higher in 1995 than in 1990. However, the increase in electricity output over the same period was nearly 13%, so the greenhouse gas intensity of electricity supply actually declined.

Cars, light trucks and aircraft accounted for nearly all of the increase in transport CO₂. This was offset by reductions in emissions from medium and heavy trucks, coastal shipping and rail.

Following the IPCC Guidelines, fuels used by international transport (international aviation and marine bunkers) are reported separately from the national inventory. In 1995, bunker fuels supplied in Australia for international transport generated 9 Mt of CO₂ emissions, 33% more than in 1990.

Table 3.3 Total and net CO₂ emissions by sector, 1990 to 1995, excluding land clearing

	1990 Mt CO ₂	1991 Mt CO ₂	1992 Mt CO ₂	1993 Mt CO ₂	1994 Mt CO ₂	1995 Mt CO ₂	% Change 90 to 95
Electricity generation	128.7	131.1	134.2	134.6	135.8	141.1	9.6
Fuel use in industry	47.4	46.7	44.5	44.7	45.3	47.8	0.8
Other stationary	27.0	28.1	28.2	30.1	30.1	31.4	16.2
Road transport	52.8	51.7	52.6	53.8	55.2	56.9	7.8
Other transport	6.8	7.2	7.8	7.3	7.5	8.3	22.1
Industrial processes	6.7	6.3	6.2	6.5	7.3	7.0	4.5
Fugitive	3.8	4.3	4.5	4.2	4.3	4.2	10.5
Waste	0.0	0.0	0.0	0.0	0.0	0.02	-
Total emissions	273.1	275.4	278.0	281.2	285.5	296.7	8.6
Net Changes in Forest & Other Woody Biomass	-23.1	-24.2	-25.5	-24.8	-23.3	-21.1	-8.7
Pasture improvement	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	0.0
Total sinks	-31.1	-32.2	-33.5	-32.8	-31.3	-29.1	-6.4
Net emissions	242.1	243.2	244.5	248.4	254.2	267.6	10.6

Excludes Forest & Grassland Conversion Subsector.

Methane

Australia's CH₄ emissions amounted to about 5 Mt in 1995, excluding land clearing – equivalent to 108 Mt CO₂ (Table 3.4). This total was about the same as reported in 1990.

The Agriculture Sector accounted for nearly 61% of national CH₄ emissions. Livestock generated three-quarters of Agriculture Sector CH₄ emissions, as a by-product of microbial fermentation associated with the digestion of feed and through the decomposition of animal wastes. Smaller quantities of CH₄ were generated in rice cultivation (CH₄ is emitted when fields are flooded and organic matter decays under anaerobic conditions), through burning savannas to increase grass production, and in the field burning of crop residues.

Agriculture Sector CH₄ emissions were about 2% lower in 1995 than in 1990. This was due largely to a drought-related reduction in livestock numbers during most of the period, and a reduction in crop production. There was some recovery in livestock numbers between 1993 and 1995, but the effect of this on the inventory was dampened by the fact that emissions are reported as three-year averages.

Fugitive emissions from fuels accounted for about 20% of national CH₄ emissions. More than 78% of these fugitive emissions came from the release of CH₄ in mining coal for local use and for export.

The rest was mainly leakage from natural gas distribution. Fugitive CH₄ emissions declined slightly between 1990 and 1995 for two main reasons – a gradual shift in coal production from underground mines to less CH₄-intensive open cut mines, and a major leak reduction program in the Sydney gas reticulation system.

The other significant contributor to CH₄ emissions was the Waste Sector, which accounted for about 15% of the national total. More than 92% of the CH₄ emissions from the Waste Sector were generated from anaerobic decomposition of organic matter in landfills. As the methodology takes into account estimates of the average mass of waste sent to landfill over a 25-year period, there is a considerable time lag between changes in waste disposal practices and emissions.

The balance of waste emissions resulted from anaerobic decomposition of organic matter in sewerage facilities during treatment and disposal of wastewater. Emissions of CH₄ from these processes were about 11% higher in 1995 than in 1990.

The remaining 4% of national CH₄ emissions came from the incomplete combustion of fossil fuels and biofuels.

The level of confidence in CH₄ emissions estimates is medium to low. Uncertainty for estimates of livestock CH₄ emissions, the largest share of the inventory, ranges from 20% to 80%. For fugitive emissions uncertainty is greater than 20%, and for waste emissions greater than 50%.

Table 3.4 Total CH₄ emissions by sector, 1990 to 1995, excluding land clearing

	1990 Mt CH ₄	1991 Mt CH ₄	1992 Mt CH ₄	1993 Mt CH ₄	1994 Mt CH ₄	1995 Mt CH ₄	% Change 90 to 95
Stationary Energy	0.08	0.08	0.08	0.09	0.09	0.09	12.5
Transport	0.03	0.03	0.03	0.03	0.03	0.03	0
Fugitive	1.05	1.02	1.06	1.02	1.02	1.02	-2.9
Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.00	0
Agriculture	3.22	3.23	3.16	3.16	3.14	3.15	-2.2
Forestry & Other	0.06	0.06	0.06	0.06	0.06	0.06	0
Waste	0.70	0.72	0.74	0.75	0.77	0.78	11.4
Total	5.14	5.14	5.13	5.11	5.11	5.13	-0.2
Total CO ₂ -e	107.94	107.94	107.73	107.31	107.31	107.73	-0.2

Excludes Forest & Grassland Conversion Subsector.

Nitrous oxide

Australia's N₂O emissions were 0.084 Mt in 1995 (excluding land clearing), equivalent to 26 Mt CO₂ (Table 3.5). This total was about 6% more than in 1990.

Agriculture accounted for more than 82% of national N₂O emissions. Most of this N₂O was produced from the application of fertiliser to agricultural soils, and from animal wastes. Burning savannas to increase grass production and field burning of agricultural residues accounted for the balance. Agriculture Sector N₂O emissions remained virtually unchanged between 1990 and 1995.

Emissions from the combustion of transport fuels in the Transport Sector accounted for almost 12% of the N₂O inventory. Emissions of N₂O from transport nearly doubled between 1990 and 1995, because of the increase in the number of light vehicles with three-way catalytic converters.

The level of confidence in N₂O emissions estimates is low. Uncertainty for estimates of Agriculture Sector N₂O emissions, the largest share of the inventory, is greater than 80%, and for transport emissions greater than 20%.



Table 3.5 Total N₂O emissions by sector, 1990 to 1995, excluding land clearing

	1990	1991	1992	1993	1994	1995	%
	Mt N ₂ O	Mt N ₂ O	Mt N ₂ O	Mt N ₂ O	Mt N ₂ O	Mt N ₂ O	Change 90 to 95
Stationary Energy	0.003	0.003	0.003	0.003	0.003	0.003	0
Transport	0.005	0.006	0.007	0.008	0.009	0.010	200
Fugitive	0.000	0.000	0.000	0.000	0.000	0.000	0
Industrial Processes	0.002	0.002	0.002	0.002	0.001	0.001	-50
Agriculture	0.068	0.069	0.067	0.068	0.067	0.069	1.5
Forestry & Other	0.001	0.001	0.001	0.001	0.001	0.001	0
Waste	NE	NE	NE	NE	NE	NE	NE
Total	0.079	0.081	0.080	0.082	0.081	0.084	6.3
Total CO ₂ -e	24.49	25.11	24.78	25.42	25.11	26.04	6.3

Excludes Forest & Grassland Conversion Subsector.

Perfluorocarbons

PFCs are generated in the aluminium production process. Improvements in processing have resulted in emissions declining from about 720 tonnes in 1990 (equivalent to 5 Mt CO₂) to about 210 tonnes in 1995 (1 Mt CO₂-e), a fall of about 70%.

Indirect greenhouse gases

Emissions of indirect greenhouse gases are summarised in Table 3.6. There were significant reductions in emissions from the Transport and Agriculture Sectors, which account for the majority of NO_x, CO and NMVOC emissions.

The reduction in transport emissions was due mainly to the increasing number of light vehicles with three-way catalytic converters. The reduction in agriculture emissions was due mainly to a fall in savanna burning activity.

Table 3.6 Total emissions of indirect greenhouse gases, 1990 and 1995, excluding land clearing

	1990	1995	% Change
	Mt	Mt	90 to 95
NO _x	2300	2137	-7.0
CO	19925	16232	-18.5
NMVOC	2115	1841	-13.0
SO ₂	NA	1.4	NA

Excludes Forest & Grassland Conversion Subsector.

LAND CLEARING

In 1995, emissions from land clearing totalled the equivalent of 85 Mt of carbon dioxide, a decline of 38 Mt or about 31% from the 123 Mt emitted in 1990. However, there is considerable uncertainty associated with these estimates. A major effort is being devoted to improving the confidence levels associated with these emissions.

Land clearing methodology

A new methodology has been developed with three significant changes from that used in the first National Communication: a preliminary land use change model has been introduced; estimates of biomass density per hectare have been improved; and woody vegetation has been included in calculations of regrowth for the first time.

The land use change model developed for the purpose of projections work provides a more objective method of deriving a time-series for historic clearing (this series was used to ensure compatibility between the projections being developed and the current inventory).

Uncertainty estimates currently stand at about $\pm 30\%$ for rate of change in area cleared and $\pm 40\%$ for change in carbon per unit area. These represent an improvement in confidence, as the error for each of these components was previously estimated to be of the order of $\pm 50\%$. Preliminary satellite information on land clearing rates, especially in Queensland, have been instrumental in significantly improving the estimates. Work is also progressing on the development of a continental land cover change map from 1981 to 1995 using satellite data.

The recent IPCC expert meeting held in Australia on biomass burning and land use change and forestry acknowledged the importance of vegetation thickening (woody weed invasion into pastures) in Australia and endorsed its inclusion in future inventory. However, estimation of the sink performance and geographic spread of woody weeds still requires quantification and peer review of data. Soil carbon emissions, resulting from soil disturbance, still remain the most uncertain aspect of emissions associated with land clearing. Major work is being undertaken to determine an Australian soils profile; this is a major area of uncertainty requiring long term effort and sizeable resources.

Overview of land clearing emissions

Trends in key components of the Forest and Grassland Conversion Subsector emissions from 1990 to 1995 are shown in Table 3.7.

Table 3.7 Carbon dioxide equivalent emissions from land clearing 1990 to 1995 (Mt)

	1990	1991	1992	1993	1994	1995	Mt CO ₂ -e	%
	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	Mt CO ₂ -e	change	change
							1990-1995	1990-1995
EMISSIONS								
Clearing of vegetation:								
(a) Burning	64.4	47.9	47.4	47.1	47.3	47.1	-17.3	-26.9
(b) Decay of debris	5.0	5.3	5.7	6.0	6.3	6.7	+1.7	+34.0
(c) Soil (including roots)	85.1	86.3	76.6	78.0	62.1	52.8	-32.3	-38.0
Total	154.5	139.5	129.7	131.1	115.7	106.6	-47.9	-31.0
SINKS								
Regrowth	31.9	31.2	29.2	28.4	23.6	22.0	-9.9	-31.0
NET EMISSIONS*	122.6	108.3	100.5	102.7	92.1	84.6	-38.0	-31.0

* Note: There is a high uncertainty in these estimates of net emissions at this point.

Emissions from land clearing are not included in the aggregate greenhouse gas emissions total for Australia already presented in this chapter because of the high degree of uncertainty underlying the emissions estimates in this area. This sector, with a best estimate of net emissions in 1995 amounting to 85 Mt, is an important contributor to national emissions, and showed a significant decrease from the estimated 123 Mt emitted in 1990.

Emissions from land clearing in 1995 were made up of around 48 Mt of CO₂-e from burning of cleared vegetation (all occurring in the year of burning), almost 7 Mt from the decay of debris not burnt, and around 53 Mt released from roots and soil disturbed in the clearing process. Removals are made up of 22 Mt of CO₂-e from regrowth.

An analysis of subsectoral emissions shows that there was a significant drop in emissions from land clearing activities due mainly to a reduction in emissions from burning and the diminishing effect of extensive past (1960s and 1970s) land clearing on below ground carbon dioxide emissions. The



pattern of soil carbon emissions is consistent with the IPCC methodology assumption of linear decay of soil carbon. Net emissions from land clearing declined from almost 123 Mt CO₂-e in 1990 to around 85 Mt CO₂-e in 1995 as indicated in Table 3.7. However, there is considerable uncertainty associated with these estimates.

Regrowth of cleared vegetation results in absorption of CO₂ from the atmosphere and constitutes a significant sink. Carbon sequestration decreased between 1990 and 1995 from almost 32 Mt to 22 Mt due to reduced clearing and therefore reduced regrowth. The diminishing regrowth sink has had a reduced offsetting effect on emissions.

Emissions profile

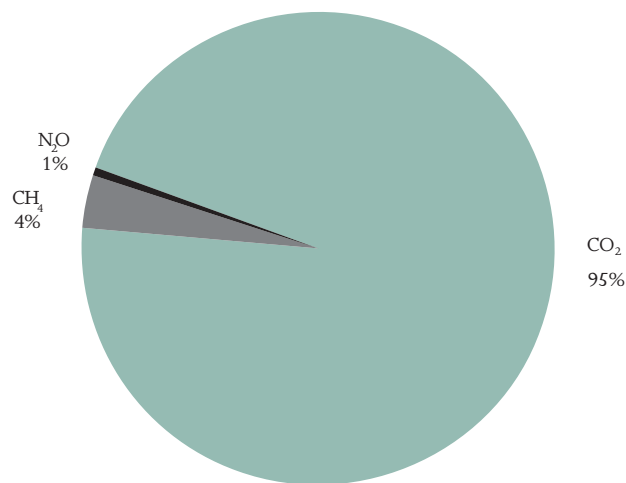
Land clearing emissions are dominated by CO₂, which contributes almost 96% of the total greenhouse gas emissions associated with this activity (see Table 3.8). However, emissions associated with land clearing have declined by around 31% over the 1990 to 1995 period, as have CO₂ emissions. CH₄ and N₂O, which together contribute the remaining 4% of emissions, have also declined significantly over this period.

Consequently, the contribution of land clearing emissions to Australia's total net emissions is declining with time.

Table 3.8 Land clearing greenhouse gas emissions and changes by gas, 1990 and 1995 (Mt CO₂-e)

	1990 Mt CO ₂ -e	1995 Mt CO ₂ -e	Mt CO ₂ -e Change	% Change
CO ₂	117.6	81.0	-36.6	-31.1%
CH ₄	4.3	3.1	-1.2	-27.9%
N ₂ O	0.8	0.5	-0.3	-37.5%
Total	122.7	84.6	-38.1	-31.1%

Figure 3.4 Share of emissions by greenhouse gas, 1995 (Mt CO₂-e) for land clearing



AGGREGATE EMISSIONS PROFILE

Australia's aggregate emissions in 1995, including all sectors and all gases, are illustrated in Figure 3.5 (a) and (b). Energy related emissions dominate Australia's emissions profile, contributing more than 65% of total emissions in 1995. The non-energy sectors of Agriculture and Land Use Change and Forestry also make significant contributions to Australia's net greenhouse gas emissions, totalling almost 30%.

CO₂ dominates Australia's greenhouse gas emissions profile, contributing 72% of Australia's total net emissions in 1995. The Energy Sector and the Land Use Change and Forestry Sector are the main contributors to CO₂ emissions (98%). CH₄ is also a significant greenhouse gas for Australia, contributing 23% of total net emissions in 1995 due to our large Agriculture Sector.

Figure 3.5(a) Contribution to total CO₂-e emissions by sector 1995

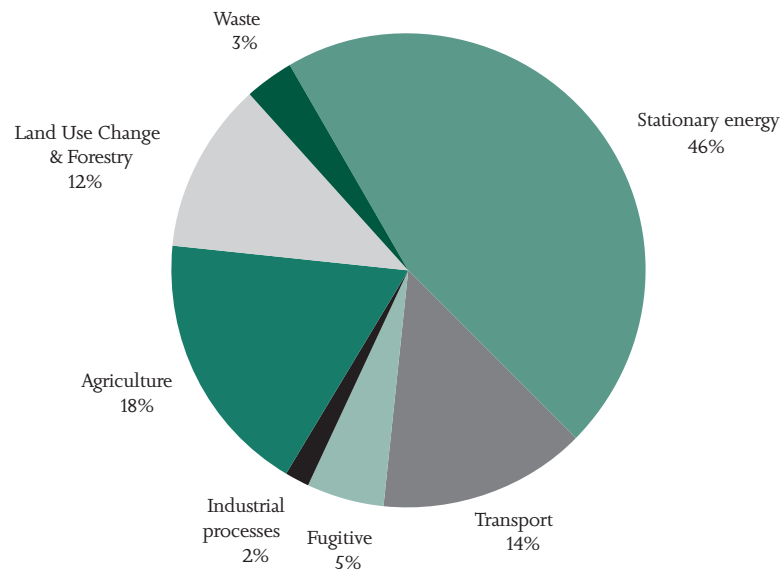
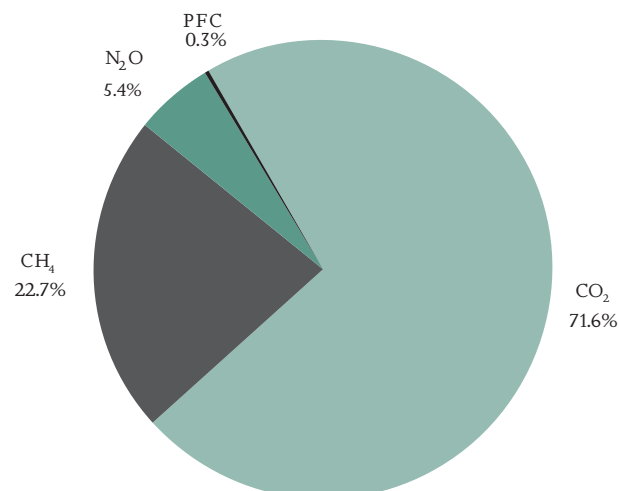


Figure 3.5(b) Contribution to total CO₂-e emissions by gas, 1995



METHODOLOGY

Improvements to IPCC default methodology

The Australian methodology is an advance over the IPCC methodology in that it contains:

- a more detailed categorisation of energy emission sources;
- a clearer accounting in the calculation of emissions from fuel combustion and sequestration of carbon in durable products and materials;
- more detail on oil and gas production and refining;
- algorithms and emission factors for coal mining and biosphere emissions that are based on actual Australian research;
- a more detailed categorisation of industrial process and waste emissions; and
- the treatment of most coke oven gases as energy rather than industrial emissions.

All departures from the default methodology are in accordance with the IPCC guidelines, lead to greater detail, and are fully documented in the Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks (NGGIC 1996 and 1997).

Changes since the last published inventory

There have been a number of changes to the Australian methodology and improvements in input data since Australia's first National Communication. The emissions calculated for 1990 are lower than the 1990 emissions reported previously.

The reduction in emission estimates is the result of more accurate input data, indicating that lower clearing rates and lower biomass densities per hectare should be used in the treatment of emissions from the Land Use Change and Forestry Sector (Sector 5). A preliminary model of historical land clearing has been introduced, and the proportion of regrowth following vegetation clearing is considered in greater detail. Nevertheless, the level of uncertainty in calculating emissions from the Forest and Grassland Conversion Subsector (land clearing) is still substantially higher than for other parts of the inventory.

Minor changes have been made to the methodology for calculating fugitive emissions from fuels (Subsector 5B). In accordance with IPCC guidelines, a methodology for estimating emissions of SO₂ in the energy and industrial processes sectors has been included.

Revised (lower) Global Warming Potential (GWP) values adopted by the IPCC have been applied since the previous Communication. For the direct greenhouse gases included in the Australian Inventory, the current GWP values are 1 for CO₂, 21 for CH₄, 310 for N₂O, 6500 for CF₄ and 9200 for C₂F₆ for the 100-year time horizon. This affects the calculation of total emissions, which are summed using the carbon dioxide equivalence (CO₂-e) of non-CO₂ gases, and should be allowed for in any comparison with totals published previously.

Confidence and uncertainty

Uncertainties in estimation of greenhouse gases currently arise from three main sources:

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

In the Australian Inventory, three levels of confidence have been adopted in accordance with the IPCC methodology: high, medium and low (see Table 3.8). These are largely conceptual, and based on the

professional judgement of those compiling the methodology and the inventories rather than on rigorous quantitative analysis.

The criteria used to define high, medium and low levels of confidence in the different sectors reflect the quality of the activity data generally available in the sector and the confidence with which the relationships between activity and emissions have been established. For example, the quality of activity data on energy use is high and the relationships between fuel combustion and emissions are comparatively simple, so the confidence in emissions estimates is much higher in the Energy Sector than in other sectors.

Table 3.8 Confidence levels

Level of Confidence	Energy, Transport, Fugitive Emissions	Industry, Waste	Agriculture, Forestry, Land Use
High	Uncertainty < 5%	Uncertainty < 10%	Uncertainty < 20%
Medium	Uncertainty 5-20%	Uncertainty 10-50%	Uncertainty 20-80%
Low	Uncertainty > 20%	Uncertainty > 50%	Uncertainty > 80%

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

- < 5% for estimates of carbon dioxide emissions from fuel combustion and > 20% for all other gases from fuel combustion;
- > 20% for fugitive fuel emissions;
- < 10% for estimates of carbon dioxide and PFCs from industrial processes;
- 20-80% for emissions from agriculture;
- > 80% for emissions from land use change and forestry; and
- > 50% for emissions from waste.

Activity data and emissions data

Activity data consist of information such as the consumption of fossil fuels, livestock numbers, crop production and the amount of organic waste sent to landfill. Emissions data describes the relationship between the activity and the production of greenhouse gases - for example the mass of CO₂ released per mass of fuel burned.

While activity data tend to vary from year to year, emissions data tend to be constant (for example when related to the chemical composition of petroleum fuels) or change more slowly over time (for example when related to the characteristics of the livestock herd, or of the stock of industrial equipment in which fuel is burned).

The time relationship between an activity and the consequent greenhouse gas emission (or removal) may be complex, especially for biological and waste processes. The emissions from such activities may occur over a long period, so in some cases the nominal emissions in a particular year are calculated from averages of activity levels over a number of previous years - up to 20 years in the case of long-term loss of soil carbon from land use change.

Reporting, averaging and adjustments

The reporting year for greenhouse gas emissions is the Australian financial year, which runs from July to June. For example, 1995 means the period from 1 July 1994 to 30 June 1995.

The inventories for fuel combustion and fugitive emissions, industrial processes and solvents reflect fuel consumption and industrial process activity in the reporting year. There are no adjustments for climate or any other factor.



Emissions from livestock and agriculture, land use change and forestry and waste embody 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 these sectors, the emissions in any particular year are affected by actions taken in that year and in previous years.

In accordance with the IPCC Guidelines, estimates for the Agriculture Sector and the Land Use Change and Forestry Sector represent average emissions over a period of several years. For Agriculture, a three-year average is consistently applied, while for the Land Use Change and Forestry Sector averaging of emissions ranges from three to twenty years, depending on the sub-component involved. In the 1995 Inventory, emissions estimates are based on two-year averages only, since data for 1996 are not yet available.

Double counting and carbon sequestration

The simplified estimation techniques used in inventory construction may result in the double counting of emissions. The two areas where this may occur are in the estimation of emissions from fuel combustion and from the manufacture of products that use fuels as raw materials. Detailed information on how the Australian methodology treats double counting and carbon sequestration can be found in the Australian Methodology for Estimating Greenhouse Gas Emissions from Sources and Sinks S Workbooks 1.1, 2.1 and 7.1. (NGGIC 1996). These processes can be summarised as follows:

- carbon is sequestered in plastics, coal products such as benzene, toluene and xylene, and raw steel as fuel consumption data are therefore reduced accordingly;
- some chemicals such as petroleum coke and methanol are fully imported into Australia, and therefore no adjustment is made to the fuel consumption data;
- where fuels are consumed by other industries as a raw material, emissions are allocated to the consuming industry;
- petroleum coke used to make carbon anodes in aluminium production is reported under industrial emissions, and the energy emissions attributed to the aluminium industry are correspondingly reduced;
- captured methane used in mine site electricity generation is excluded from fugitive emissions data and reported under electricity generation; and
- fugitive CH₄ emissions from natural gas distribution are subtracted from the estimate of total natural gas used in energy combustion.

Gaps

A lack of emissions data to date from industry means that no estimates of HFC or SF₆ emissions are so far available, although an Australian methodology exists. It is expected that these emissions will be estimated beginning with the 1996 inventory. Neither of these substances is manufactured in Australia.

LIST OF METHODOLOGY WORKBOOKS

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 (1997) Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, National Greenhouse Gas Inventory Committee, Canberra

Workbook for Carbon Dioxide from the Biosphere, National Greenhouse Gas Inventory Committee, Workbook 4.2 1997, Canberra



LIST OF GREENHOUSE GAS INVENTORIES

NGGIC (1994) National Greenhouse Gas Inventory 1988 and 1990, National Greenhouse Gas Inventory Committee, Canberra

NGGIC (1996a) National Greenhouse Gas Inventory 1988 to 1994 (7 volumes), National Greenhouse Gas Inventory Committee, Canberra

NGGIC (1996b) National Greenhouse Gas Inventory 1988 to 1994: Summary and Analysis of Trends, National Greenhouse Gas Inventory Committee, Canberra

NGGIC (1997a) National Greenhouse Gas Inventory 1995, National Greenhouse Gas Inventory Committee, Canberra

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

NGGIC (in press) National Greenhouse Gas Inventory 1988 to 1995: Summary and Analysis of Trends, National Greenhouse Gas Inventory Committee, Canberra

Table 3.9 Direct greenhouse gas emissions by subsector, 1995

	Emissions (Gg)				CO ₂ -equivalent Emissions (Gg)				
	CO ₂	CH ₄	N ₂ O	PFC	CH ₄ (a)	N ₂ O (b)	PFC (c)	Total	%
Total National Emissions and Removals	348589	5262.3	85.5	0.21	110508	26510	1432	487039	100.0
1 All Energy (Combustion and Fugitive)	289688	1130.6	12.6		23742	3920		317351	65.2
A Fuel Combustion	285464	113.3	12.6		2378	3900		291743	59.9
1 Energy & Transformation Industries	156807	2.3	1.6		47	482		157337	32.3
a Electricity and Heat Production	141084	1.5	1.5		32	454		141569	29.1
b Petroleum Refining	6825	0.1	0.1		3	19		6847	1.4
c Solid Fuel Transformation, etc	8899	0.6	0.0		13	10		8921	1.8
2 Industry	47841	1.3	0.3		28	97		47965	9.8
3 Transport (Mobile Sources)	65185	25.6	9.8		537	3035		68758	14.1
Road Transport	56907	20.5	9.6		431	2968		60306	12.4
Rail Transport	1530	0.1	0.0		1	14		1546	0.3
Domestic Air Transport	4442	0.8	0.1		16	39		4497	0.9
Domestic Marine Transport	1951	2.4	0.0		50	13		2014	0.4
Other Mobile Sources	355	1.9	0.0		39	2		395	0.1
4 Small Combustion	13646	0.8	0.1		17	21		13684	2.8
5 Other	1984	0.2	0.0		4	11		1999	0.4
6 Biomass Burned for Energy	N/A	83.1	0.8		1746	254		2000	0.4
B Fugitive Emissions from Fuels	4225	1017.3	0.0		21363	20		25608	5.3
1 Coal Mining	NE	795.8			16712			16712	3.4
2 Oil & Natural Gas Systems	4225	221.5	0.0		4651	20		8896	1.8
2 Industrial Processes	7018	3.8	1.4	0.21	80	434	1432	8964	1.8
A Iron & Steel	0	3.5	N/A		72	N/A		72	0.0
B Non-Ferrous Metals	1895	NE	NE	0.21	NE	NE	1432	3327	0.7
C Inorganic Chemicals	NE	NE	1.4		N/A	434		434	0.1
D Organic Chemicals	NE	0.4	NE		8	NE		8	0.0
E Non-Metallic Mineral Products	5123	NE	N/A		NE	N/A		5123	1.1
F Other Industry	N/A	NE	N/A		NE	N/A		NE	NE
3 Solvent and Other Product Use									
4 Agriculture	N/A	3146.0	68.7		66065	21297		87362	17.9
A Enteric Fermentation	N/A	2768.2			58133			58133	11.9
B Manure Management	N/A	84.2	25.3		1768	7852		9621	2.0
C Rice Cultivation	N/AN/A	30.9			648			648	0.1
D Agricultural Soils			30.1			9319		9319	1.9
E Prescribed Burning of Savannas		255.1	13.1		5358	4055		9413	1.9
F Field Burning of Ag Residues		7.5	0.2		158	71		229	0.0
G Other									
5 Land Use Change & Forestry	51866	203.7	2.8		4277	859		57002	11.7
A Changes in Forest & Woody Biomass	-21113							-21113	-4.3
B Forest & Grassland Conversion	80972	148.4	1.8		3116	543		84631	17.4
C Abandonment of Managed Lands	NE							NE	NE
D Other	-7993	55.3	1.0		1161	316		-6516	-1.3
6 Waste	17	778.3			16344			16361	3.4
A Solid Waste Disposal on Land	17	721.7			15156			15173	3.1
B Wastewater Treatment		56.6			1188			1188	0.2
C Waste Incineration									
D Other Waste									
International Bunkers (d)	8533	0.9	0.2		20	76		8628	

(a) GWP = 21

(b) GWP = 310

(c) Weighted average GWP = 6745

(d) Not part of inventory



Table 3.10 Summary report for National Greenhouse Gas Inventories 1990 to 1995 (CO₂-equivalent)

	1990	1991	1992	1993	1994	1995
	Gg	Gg	Gg	Gg	Gg	Gg
1 All Energy (Fuel Combustion + Fugitive)	293,307	295,575	299,530	301,840	305,640	317,351
A Fuel Combustion	267,298	269,735	272,663	276,168	279,902	291,743
1 Energy & Transformation Industries	142,284	145,802	149,011	150,297	151,360	157,337
2 Industry	47,487	46,803	44,642	44,843	45,462	47,965
3 Transport (Mobile Sources)	61,824	61,338	63,159	64,152	65,986	68,758
4 Small Combustion	12,213	12,304	12,625	13,109	13,229	13,684
5 Other	1,682	1,643	1,344	1,812	1,876	1,999
6 Biomass Burned for Energy	1,808	1,845	1,882	1,955	1,989	2,000
B Fugitive Emissions from Fuels	26,009	25,840	26,867	25,672	25,738	25,608
1 Coal Mining	15,903	15,968	16,586	16,527	15,931	16,712
2 Oil & Natural Gas Systems	10,106	9,872	10,281	9,145	9,807	8,896
2 Industrial Processes	12,084	11,722	10,415	10,173	9,879	8,964
3 Solvent & Other Product Use	NA	NA	NA	NA	NA	NA
4 Agriculture	88,796	88,998	87,089	87,291	86,931	87,362
A Enteric Fermentation	59,098	59,186	58,206	58,019	57,994	58,133
B Manure Management	9,601	9,618	9,508	9,542	9,555	9,621
C Rice Cultivation	477	525	527	596	607	648
D Agricultural Soils	8,308	8,432	8,432	8,742	8,835	9,319
E Prescribed Burning of Savannas	11,097	11,024	10,217	10,202	9,796	9,413
F Field Burning of Agricultural Residues	215	213	199	190	144	229
G Other						
5 Land Use Change & Forestry (a)(b)	93,194	77,890	68,521	71,475	62,528	57,002
A Changes in Forest & Other Woody Biomass(a)	-23,083	-24,167	-25,509	-24,818	-23,280	-21,113
B Forest & Grassland Conversion (a)(b)	122,621	108,343	100,396	102,671	92,193	84,631
C Abandonment of Managed Lands	0	0	0	0	0	0
D Other (d)	-6,344	-6,286	-6,365	-6,378	-6,385	-6,516
6 Waste	14,792	15,122	15,450	15,777	16,105	16,361
A Solid Waste Disposal on Land	13,650	13,965	14,280	14,595	14,910	15,173
B Wastewater Treatment	1,142	1,157	1,170	1,182	1,195	1,188
C Waste Incineration	NE	NE	NE	NE	NE	NE
D Other Waste	N/O	N/O	N/O	N/O	N/O	N/O
International Bunkers (e)	6,478	6,456	6,646	7,005	7,319	8,614

(a) Emissions value indicated is the net of emissions and removals.

(b) The inventory for the Forest and Grassland Conversion component of this value is subject to large uncertainties.

(c) Emissions from in-house production of lime and limestone/dolomite in Iron & Steel accounted under Non-Metallic Mineral Products.

(d) Carbon removal from pasture improvement.

(e) Not included in national emissions and removals.

Policies and measures

POLICY CONTEXT

Australia's greenhouse policies and response measures are based on the comprehensive approach of addressing all sources, sectors and sinks of greenhouse gases. This approach is a key feature of the Framework Convention on Climate Change.

Simultaneous with signing the Climate Change Convention, Australia adopted a National Greenhouse Strategy in 1992. The Strategy was developed by the Commonwealth, State and Territory Governments in partnership with the Australian Local Government Association. It was formally endorsed by heads of government through the Council of Australian Governments (CoAG).

Our First National Communication, presented in 1994, set out progress on implementation of policies and measures to that point in time. Since then, additional measures have been adopted to enhance response efforts.

In this chapter, policies and measures are grouped according to individual gases as well as by sector of economic activity. An overview of the policies and measures responsible for the most significant reductions in greenhouse gas emissions is presented in Tables 4.1, 4.2, 4.3 and 4.4 at the end of the chapter.

In accordance with provisions in the National Greenhouse Strategy, a major review of the Strategy is well under way. The new Strategy will be finalised by June 1998.

As part of the ongoing enhancement of the range and effectiveness of policies and measures, the Prime Minister announced a Commonwealth package of strengthened greenhouse measures on 20 November 1997. The \$180 million five-year package includes completely new measures and a substantial expansion of existing programs. It will take Australia to world best practice and enhance the nation's competitive strengths.

The new measures contained in the Prime Minister's greenhouse package were finalised at a late stage in the production of this Communication and were not able to be included in the projections presented in Chapter 5. They are indicated in this chapter by italics.

MEASURES RELATED TO CARBON DIOXIDE EMISSIONS AND SINKS

Carbon dioxide is the dominant greenhouse gas, contributing about 72% of Australia's net greenhouse gas emissions in 1995. The main sources are combustion of fossil fuels for stationary energy and transport.

Cross-sectoral

Establishment of the Commonwealth Greenhouse Office

As part of the Prime Minister's greenhouse package, a Commonwealth Greenhouse Office will be created within the Department of the Environment. This office will be responsible for the coordination of domestic climate change policy and delivery of greenhouse response programs. It will be the lead Commonwealth Government agency on greenhouse matters and will provide a central point of contact for industry and other stakeholders.

Local Government

Local councils throughout Australia are influencing greenhouse gas emissions and potential climate change impacts through the delivery of their statutory responsibilities and through innovative programs involving local communities. It is estimated that Local Government could have an influence over activities accounting for 50% of emissions. Many local councils are examining their own operations in order to reduce greenhouse gas emissions. For example, a number of councils are conducting retro-fits of council-owned facilities and promoting alternative transportation, while others have employed greenhouse officers to progress awareness within council and the community of climate change issues.

Local Government is also using its significant role in the planning and establishment of urban subdivisions, development approvals and siting of buildings, and its influence in transport choices, to reduce greenhouse gas emissions. Councils are promoting awareness of greenhouse issues through education programs, and by providing incentives for, and encouragement of, energy efficient choices in construction and consumer habits.

Cities for Climate Protection – Australian campaign

Local Government, with support from the Commonwealth Government, has initiated a pilot of the Cities for Climate Protection Campaign which is based on the international model established under the International Council of Local Environment Initiatives. Participating local councils set a greenhouse emission reduction target for their own corporate operations and their community's activities. The campaign provides a formal framework and tools to help councils reach their reduction targets. The program also includes a public information component described in Chapter 9, 'Education, training and public awareness'.

Under the Prime Minister's new package of strengthened measures the extensive uptake of this scheme will be supported, with the aim of recruiting 300 local councils throughout Australia by the year 2003.

National Sustainable Energy White Paper

The Commonwealth Government published a Green Paper on sustainable energy policy in December 1996 which outlines the issues to be covered in a subsequent policy statement (a White Paper) expected to be released in 1998. The White Paper will set out a broad framework for energy policy integrating economic and environmental objectives over a 25-year timeframe. Key elements will include energy market reform, conventional and alternative technologies (including renewable energy technologies), energy efficiency, R&D, international collaboration and institutional arrangements.

The National Energy Efficiency Program

The Commonwealth Government's National Energy Efficiency Program (NEEP) provides a range of advisory and information services to all sectors of the economy and the community generally. These services cover such matters as basic information on energy use and access to data on high efficiency technologies through networks such as the International Energy Agency's Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). NEEP also provides a framework through which the Commonwealth, State and Territory Governments coordinate the development and implementation of initiatives such as product energy labelling, minimum energy performance standards and building energy performance benchmarks.

Efficiency standards for power generation

The development and implementation by 2000 of efficiency standards for fossil fuel use in electricity generation was announced by the Prime Minister as part of his package of strengthened measures. The Commonwealth Government will work with the States to ensure the adoption of the best practicable new technology in each fossil fuel class, lowering emissions per unit of useful energy. Standards will apply to new electricity generation projects, significant refurbishments and existing generation.

Electricity supply industry reform

Electricity is the main source of energy in the residential and commercial sectors and for some energy intensive industries such as aluminium production. Coal-fired power stations contribute almost 27% of Australia's net emissions and all stationary energy sources contribute 46%. Emissions from stationary energy sources increased by more than 8% between 1990 and 1995.

A range of measures are targeted at reducing the intensity of supply, and improving the efficiency of electricity use. Key measures to this end include reform of energy markets and the Greenhouse Challenge Program (see below).

Electricity industry reform in Australia was initiated by CoAG as part of broader economic reforms. Major restructuring of the industry has been taking place following agreement to establish a fully competitive integrated national electricity market across the generation, retail and distribution sectors by 2001.

The first stage of a competitive electricity market in southern and eastern Australia was introduced in Victoria, NSW and the ACT in 1997. South Australian generators will join the national market when the market systems are fully operational in 1998, while Queensland and Tasmania will join following grid interconnection.

The new market arrangements separate the industry's sectors to allow for competition in generation, in purchasing from the central dispatch 'pool' and in the provision of services at the retail level. A system of light-handed national competition regulation of the remaining monopoly (network) elements will encourage increased efficiencies through time, and appropriate investment in networks and in upstream and downstream markets.

The reforms also encourage the removal of existing capital subsidies and cross-subsidies, so as to promote cost-reflective pricing. This is a key measure for the promotion of efficient competition in supply by embedded cogeneration and renewable energy sources. It will also promote more sensible patterns of energy use through greater incentives for investment in energy efficiency. In recognition of the importance of pricing to efficient, environmentally sound outcomes, a review of the proposed network pricing arrangements will be undertaken in 1998.

Enhanced energy market reform measures contained in the Prime Minister's announcement will accelerate electricity reform, deliver integrated and compatible national frameworks for gas and electricity by 2002 and, in cooperation with the States, develop means to identify the greenhouse intensity of energy sources in energy market trading pools by 2001.



Demand management

Under the former market arrangements, the Victorian State Electricity Commission invested A\$33 million in business energy efficiency measures that reduced demand by around 100 megawatt-hours per year, while a similar plan in South Australia delivered energy saving of A\$8 million per year. More recently, the Victorian Government established the 'Energy Smart Companies' program, with 300 companies participating to implement energy management strategies.

Important outcomes of reforms in the electricity sector are expected to include the development of an energy services industry and demand management initiatives directed at consumers. Integrated energy utilities are already emerging, offering demand management services and optimal fuel choice as part of a complete package of energy services. Innovative new approaches, such as performance contracting, are also appearing. It is expected that this trend will accelerate as the market develops, and as the current overcapacity in electricity supply unwinds, removing the current downward pressure on electricity prices.

Environmental regulatory changes in the NSW electricity industry

Under the NSW Electricity Supply Act of 1995, electricity retail licensees are required to develop greenhouse gas emission reduction strategy plans, and electricity distributor licensees are required to investigate demand management options prior to expanding, or increasing the capacity of, their distribution systems. The NSW Government has also capped the revenues of the operator of the power transmission system and electricity distributors for the period to 1998/99, encouraging demand management and energy efficiency initiatives. Exemptions include 'Green Power' schemes - paying a higher price for electricity produced from renewable sources - which now operate in several regions.

The Sustainable Energy Development Authority of NSW (SEDA)

As a key component of the NSW Government's reform of the electricity industry, SEDA was established to support the development, commercialisation, promotion and use of sustainable energy technologies. Discretionary funding of \$39 million has been allocated over 1996-99. SEDA has identified a potential to reduce greenhouse gas emissions by 14 Mt per annum - equivalent to about one-quarter of current emissions from the NSW electricity sector - and has launched the following programs: Energy Smart Buildings in Government; Energy Star Offices; SEDA Cogeneration Investment Program; and the Green Power Accreditation Program. An Energy Smart Homes Program was instigated recently to help councils implement energy efficient housing policies in their local areas.

Energy and environmental performance programs

The Commonwealth Government's 'Enterprise Energy Audit Program' subsidised energy audits between 1991 and 1997. These audits helped companies identify opportunities for energy savings.

Under its 'Environmental Management Program: a Business Approach', the Commonwealth Government provides assistance to companies to take up the challenge of cleaner production and waste management and of reducing greenhouse gas emissions. This program includes an Energy Management Module that helps companies quantify the savings they can make by identifying and exploiting opportunities to increase energy efficiency.

Natural gas industry reform

Natural gas is Australia's fastest growing energy source and, as a clean and efficient source of energy, has an important role to play in helping to reduce Australia's greenhouse gas emissions. The Commonwealth, State and Territory Governments agreed in February 1994 to implement reform of the gas sector to allow free and fair trade in natural gas. The primary focus of reform has been to

establish a regulatory framework to facilitate nationally consistent third-party access to transmission and distribution pipelines through the National Third-Party Access Code.

This recently finalised Code will enable market participants to deal with pipeliners on fair and reasonable terms, while providing pipeline investors with the opportunity to earn a fair and reasonable return on capital, commensurate with the risks involved. A legislative package to give effect to the Code has been finalised. Through CoAG, all Governments have agreed to implement the Code progressively during the first half of 1998.

Implementation of the Code will promote competition in the delivery of gas, leading to lower prices and greater choice for consumers and reduced input costs for key exporting industries. In conjunction with electricity reform, the Code is driving integration in the provision of gas and electricity, encouraging optimal energy choice and the increased use of cogeneration .

Cogeneration

Cogeneration is being employed increasingly by major energy consumers, with process heat utilised on site or in the immediate vicinity and the electricity generated also used on site or sold back to the grid. In 1994/95, cogeneration provided 3.4% of Australia's electricity. Users included sugar mills, basic processing industries, chemicals and refining industries, and pulp and paper manufacturers. There is considerable potential to expand the use of cogeneration in Australia. Capacity could exceed 1000 megawatts over the next decade, reducing CO₂ emissions by around 5 Mt.

In the competitive electricity market, eligible cogenerators will be subject to the same rules and conditions as other electricity market participants, removing many of the barriers faced by industry in the past. Gas market reform is expected to increase access to competitive supplies of gas, further encouraging cogeneration.

In NSW, Integral Energy has negotiated to purchase 160 megawatts of electricity from the Smithfield cogeneration plant, saving an estimated 0.5 Mt per annum of CO₂ equivalent. Two other large cogeneration projects that have been foreshadowed are a 350-megawatt plant at Botany and a 350-megawatt plant at Kurnell. In November 1996, SEDA launched its Cogeneration Investment Program, which will see \$1 million invested in small-scale cogeneration projects State-wide.

Agreement has been reached between 23 sugar mills and the Queensland Transmission and Supply Corporation for the mills to supply the grid with cogenerated electricity from renewable bagasse. All mills generate their own electricity requirements, and in addition will supply the grid with 80 megawatts of electricity in 1997/98. This amount is projected to increase to more than 100 megawatts by the year 2000. In Western Australia, the PB-Kwinana cogeneration plant is saving 0.2 Mt per year from the supply of 76 megawatts to the WA electricity grid.

Other notable cogeneration developments which are proceeding include an 80-megawatt plant at Altona in Victoria, four 40-megawatt plants at mines in Western Australia and a 180-megawatt plant at Port Adelaide in South Australia.

Renewable energy

Australia is endowed with renewable energy sources including solar energy, wind, biomass and hydro-electricity, although there are limits to the remaining available potential of the latter. This has led to Australia becoming a world leader in a number of renewable technologies, including solar water heating and photovoltaic cell technology, and renewable applications for stand-alone power supplies.

Commonwealth Government support of renewable energy includes funding for: the Australian Cooperative Research Centre for Renewable Energy and Related Greenhouse Gas Abatement Technologies; the international Centre for the Application of Solar Energy (CASE), which facilitates



technology transfer to developing countries; and the Renewable Energy Industry Program (\$4.8 million) to promote the commercialisation of renewable energy technologies. Another initiative, the 'EnergyCard', provides a low interest credit facility allowing consumers to purchase renewables and energy efficient products including solar water heaters. This was established by the Government in cooperation with industry, distributors, and the financial institutions that now run the program.

The new measures announced in November 1997 include the following initiatives for boosting the use of renewable energy.

- **Mandatory targets for the uptake of renewable energy in power supplies**

Targets will be set for the inclusion of renewable energy in electricity generation by the year 2010. Electricity retailers and other large electricity buyers will be legally required to source an additional 2% of their electricity from renewable or specified waste-product energy sources by 2010 (including through direct investment in alternative renewable energy sources such as solar water heaters). This will accelerate the uptake of renewable energy in grid-based power applications, and provide an ongoing base for commercially competitive renewable energy.

- **Renewable Energy Innovation Investment Fund (REIIF)**

The REIIF will provide funding specifically to facilitate commercialisation and application of renewable energy technologies. All initial investments will be required to be in the early stages of company development. Government funding will be provided on a competitive basis through licences to REIIF fund managers, and invested along with private sector funding on a 2:1 basis.

- **Renewable energy technology commercialisation loans and grants**

A competitive loans and grants program will provide support for, and promotion of, strategically important renewable energy initiatives that have strong commercial potential. It will be integrated with the existing Renewable Energy Industry Program.

- **Renewable energy showcase**

A few leading-edge 'showcase' projects will be selected via competitive tender for seed funding and/or promotion. These could include projects which are close to becoming commercial, such as tidal power projects; solar thermal projects; and a central photovoltaic generating project in a technology park.

- **Renewable energy technology Internet site**

Funding will be provided for the development of a sophisticated, up-to-date Internet site on renewable technologies, to provide information on technologies, examples of their application and available government assistance.

The NSW Government is providing support for the 'Green Power' renewable energy scheme, through accreditation of renewable energy suppliers by SEDA (see box). The Green Power scheme allows consumers the choice of renewable electricity. Good consumer acceptance is encouraging a rapid expansion of grid-connected renewable supplies, with almost 25 megawatts of new renewables under construction or committed as a result of the scheme.

A major solar powered residential development, at the Olympic Village Site in Sydney, will also be developed in partnership with SEDA.

Electricity utilities in South Australia and Western Australia are offering a 10% loading on normal buy-back rates for generation projects based on renewable energy sources. The 20-kilowatt Kalbarri Photovoltaic Project and the 2-megawatt Esperance wind farm in WA were the first renewable projects of their type in Australia.

Renewable energy stand-alone power supply systems are widely used in rural and remote areas of Australia. Many thousands of individual telecommunication systems, large numbers of water pumping and household power supply systems and a small but growing number of rural communities rely on renewable energy for power.

Solar hot water systems are currently installed on around 350 000 homes; exemption from sales tax is provided for the solar collector component of solar energy systems. Many Local Government authorities have encouraged the use of solar water heaters, and of solar lighting for public facilities lacking grid access.

Thirteen hydro schemes, with a combined output of 131 megawatts, have been built recently or are under construction on existing water storage dams throughout Australia. These include a 30-megawatt scheme opened in 1996 on the Ord River Dam in Western Australia.

Research, development and demonstration (RD&D)

Energy RD&D is part of a much wider technology development issue. Commonwealth Government programs, such as the 125% tax deduction for RD&D and the 'Start' program (see below), which aim to encourage industrial RD&D generally, include energy related research.

The Government is providing \$520 million over four years for the Start program, announced in 1996, to assist industry to undertake research and development with high commercial potential. Six energy projects funded since the commencement of the program cover ultra-clean coal, tunnel boring machinery for longwall mining, highwall auger open cut mining, energy storage, oil from shale, and power conditioning for solar energy. The ultra-clean coal project is aimed at realising the greenhouse benefits available from these coals, produced by a new process that removes impurities from coal. The latter two projects are developing technologies aimed at facilitating the use of renewable energy - in particular, high energy density supercapacitors for energy storage and integral power conditioning for solar electricity applications.

The Commonwealth Government also provides specific support for energy RD&D through the Australian Cooperative Research Centres (CRC) program, which includes the CRCs for Renewable Energy Technologies, Black Coal, Petroleum and Brown Coal. The Australian Research Council also funds the Photovoltaics Special Research Centre.

The CRC for Renewable Energy Technologies is spending \$64.5 million over seven years on a range of projects aimed at developing renewable energy technologies, improving the efficiency of renewable energy technologies and improving the interface between traditional and renewable power generation systems.

The two coal CRCs are undertaking research into advanced clean coal utilisation technology. The Brown Coal CRC is a world leader in the development of an integrated gasification combined cycle process that offers significant improvements in thermal efficiency, reducing both greenhouse gas emissions and the capital costs of lignite power stations. The Black Coal CRC is developing a coal gasification research facility in a joint initiative between the Commonwealth and Queensland Governments and the Australian coal industry.

This research aims to ensure Australia's electricity generation industry achieves early commercialisation of technology that can offer cost-effective reduction of greenhouse gas emissions. Demonstration projects indicate that these technologies are capable of reducing emissions by more than 20% compared with conventional coal power stations.

The NSW Government is providing \$45 million to Pacific Solar Pty Ltd to accelerate the development and commercialisation of the thin film photovoltaic cell technology produced at the University of NSW. It is also providing discretionary funding through SEDA to support the development, commercialisation and use of sustainable energy technologies.

The Victorian Government supports research and development on solid oxide fuel cells and technologies that improve the efficiency of electricity generation from brown coal and reduce greenhouse gas emissions. The NSW State Energy Research and Development Fund gives a high priority to the development of sustainable energy technologies such as solar cell and solar thermal



systems, and wind energy. Support is also directed towards efficient electricity generation, efficient electric motors, natural gas appliances and alternative transport fuels.

Transport

Carbon dioxide from the transport sector made up approximately 14% of Australia's net greenhouse gas emissions in 1995. For the period 1990–95, transport was also a major contributor to the growth in national CO₂ emissions, with emissions from this sector increasing by 11%.

The transport industry comprises a diverse range of services and activities, with greatly differing scales of operation and shares of markets. The main divisions in the industry are between passenger and freight transport, and between urban and non-urban transport. Within those categories, the mode of transport employed is the major factor to be considered in analysing and responding to greenhouse issues.

Australian Governments recognise the need to design transport policies carefully to achieve an efficient and environmentally friendly transport system, and a diverse range of measures have been adopted.

Bureau of Transport and Communications Economics (BTCE) studies

The BTCE has published a major report projecting future greenhouse gas emissions and the impacts of a number of commonly proposed measures for reducing them. This work provides, for the first time, a firm basis for comparing the cost-effectiveness of various measures for reducing greenhouse gas emissions in the transport sector. Social costs and benefits, and effectiveness in reducing emissions, were the major analytical perspectives used in the report. The BTCE has also completed work of this nature on the resurfacing of Australia's national highways.

The Australian Transport Council (ATC)

The ATC comprises Transport Ministers of the Commonwealth, State and Territory Governments. Their vision for Australia's transport system is a safe, integrated and efficient transport sector that achieves relevant best practice standards, facilitates the nation's economic development and defence, and supports its social and environmental well-being. Performance measurements for sustainability relate to demand management, transport-related pollution and waste costs, and efficiency of use of fossil fuels. Attention to these factors will decrease greenhouse gas emissions.

The ATC's environmental strategy for transport sustainability, and reduction of greenhouse gas emissions, is to balance the interests of transport providers and users with those of the community as a whole in a sustainable environment.

Environmental strategy for the automotive industry

A Commonwealth Government Environmental Strategy for the Automotive Industry, announced as part of the new measures, will significantly enhance the environmental performance of the automotive industry. The strategy will cover a range of issues including:

- *mandatory fuel efficiency labelling through Australian design rules;*
- *negotiations with the automotive industry and companies within the National Average Fuel Consumption framework to secure a 15% fuel efficiency improvement target by 2010 compared with business as usual (recognising that the scope for model and design change will increase progressively from 2003); and*
- *the development of options for challenging but realistic fuel efficiency targets for the Commonwealth Government car fleet from 2003.*

Driver education

The SA and NSW Governments are promoting fuel efficient driving techniques through driving instructor courses, driver training programs and information for learner drivers and heavy vehicle drivers.

Vehicles speed limits

In SA, speed limits on rural roads are under review for safety purposes. Any reductions will have benefits in reducing greenhouse emissions. A range of more appropriate speed limits in urban areas is also being introduced to improve safety and encourage walking and cycling.

Fleet fuel savings

A number of governments are adopting measures to improve the fuel consumption and efficiency of their fleets.

Vehicle emissions

The NSW Government is encouraging petrol companies to produce reformulated petrol and diesel which will reduce vehicle emissions. It is also involved in trials of fuel and oil additives aimed at reducing emissions. The Queensland Government is investigating options such as testing emissions on-road and at transfer of ownership, and education programs. The Northern Territory Government has introduced annual road-worthiness inspection requirements for all vehicles.

Heavy trucks

Governments have amended road transport legislation to allow for the operation of B-doubles vehicles along designated routes across Australia. These vehicles have higher levels of cartage efficiency than single articulated trucks, resulting in lower emissions per tonne/kilometre of freight carried.

Public transport

Governments are upgrading urban public transport through, for example, the introduction of alternative-fuel buses, improved urban rail systems, integrated transport systems, and improved services.

The ACT Government encourages public transport with bus-only lanes, bus traffic signal priority, 'Park 'n Ride', commuter express bus services, stored-value bus fare cards and electronically available timetables. The ACT bus fleet also includes a number of 'midi' (three-quarters standard size) buses, with more to come into operation in 1998.

Queensland's Public Transport Program aims to increase use of public transport by providing an attractive alternative to private transport with passenger service providers meeting specified performance standards and conditions. In South East Queensland, Citytrain is to be developed as a first choice for commuter and leisure transport.

Other rail projects include the electrification of the Perth suburban rail system, the opening of a new light rail system in Sydney, and improvements to city train services in Melbourne.

VicRoads supports car pooling programs by offering a computer program to match users.

Cycling

NSW, SA, ACT, WA and Qld have developed expanding networks of bicycle paths and related facilities. Commonwealth funding assisted many of these projects.

Integrated transport planning

A number of States have implemented integrated transport strategies which will help to reduce greenhouse emissions. In NSW, a whole-of-government approach is adopted in land use and transport planning. This emphasises travel demand management as a means of reducing environmental impacts, including greenhouse emissions. Approaches identified include trials of new fuel technologies, development of vehicle emission control strategies, encouragement of non-motorised forms of transport and education programs.



Queensland has a portfolio-wide Transport Coordination Plan which identifies the importance of environmental sustainability and consistency with national greenhouse objectives while promoting integrated transport and land use planning. A Transport Portfolio Environmental Framework will set broad policy direction in terms of environmental outcomes and improved performance, and provide guidance to transport agencies. A draft Integrated Regional Transport Plan for South East Queensland includes increased public transport, walking and cycling, and shared rides, restrained growth of peak period travel demand, and maintaining the environment.

The Victorian Government's integrated land use and transport strategy 'Transporting Melbourne' and 'Living Suburbs', its metropolitan policy, recognise the need for land use and transport planning to be developed and managed as a whole. They also encourage medium density housing near public transport and major activity centres.

The WA Government's Metropolitan Transport Strategy aims to reduce the trend towards increasing car use by setting future mode share targets, including increased cycling. In the ACT, new developments must comply with requirements that encourage non-motorised and public transport trips.

Urban planning and design

In order to reduce urban fringe growth, governments have since 1991 been developing design principles for new urban neighbourhoods and residential developments which contribute to urban consolidation and reduced motor vehicle dependence, and employ an intergovernmental approach to infrastructure provision and financing.

Strategic plans for major new urban developments, residential infill and major redevelopment of existing areas incorporate higher average density requirements and less prescriptive land use restrictions, providing opportunities to reduce travel distances. Strategic planning will integrate transport links with employment centres and housing. A national model code for higher housing density has been developed.

Alternative fuels

Alternative transport fuels include liquefied petroleum gas (LPG), natural gas both in compressed (CNG) and liquefied (LNG) form, ethanol from biomass, methanol from biomass or natural gas, electricity, seed oils and hydrogen.

The use of CNG and ethanol will be encouraged by the new package of strengthened measures.

- **Light commercial vehicles**

compressed natural gas (CNG) infrastructure: In collaboration with natural gas companies and Local Government authorities, the Commonwealth Government will facilitate a switch to the use of natural gas in light commercial vehicles through the establishment of a distribution network of service stations. This program aims to establish a minimum refuelling network firstly in Sydney and Melbourne, with possible extension to other major urban centres.

- **Ethanol pilot plant**

An ethanol pilot plant will be built to demonstrate new Australian technologies for the production of ethanol from wood fibres and simultaneous waste treatment. It is anticipated that the pilot plant will realise substantial net greenhouse gas reductions, with urban air quality and economic benefits greater than those available from all existing fuel ethanol production technologies.

State and Local Governments are also actively encouraging the use of alternative fuels that are less greenhouse emission intensive than petrol and diesel through a range of measures. All of these alternative fuels are currently exempt from Commonwealth excise (a loss to revenue of more than \$600 million per annum, mostly on LPG). Equipment to convert vehicles to LPG or natural gas is sales tax exempt.

Where economic and practicable, governments are fostering the use of alternative fuels in some classes of government vehicles, and are preparing for demonstrations of CNG and blended alcohol fuels in government fleets. Several hundred buses fuelled by CNG are operating in NSW, SA, WA and the ACT. The ACT's Energy Research and Development Trust Fund includes a focus on the promotion of alternative fuel vehicle technologies, particularly for CNG. The Commonwealth Government funded a fuel ethanol bounty scheme from 1994/95 to 1995/96, and an ethanol R&D program is in progress.

Rail and shipping reforms

In 1996, the Commonwealth Government announced a \$2 billion program to rejuvenate rail services by increasing private sector involvement, reducing the Government's role, and establishing a national interstate track infrastructure entity. The aim is to establish an operating environment conducive to greater private sector involvement in rail freight. Such a competitive environment is designed to enhance the role of rail freight, with reductions in greenhouse emissions.

Complementary rail reforms and upgrading are taking place in Queensland, NSW, WA, Victoria and SA. These include improved access to the rail network by multiple operators.

Shipping reform, a major component of the national transport reform agenda, is leading to the introduction of technologically advanced, fuel efficient ships handling larger cargoes more efficiently. The SA Government, for example, is encouraging improvements in the fuel efficiency of ships by facilitating provision of deep sea ports and associated land transport.

Industry

Manufacturing accounts for about one-third of Australia's total energy use, primarily in the form of electricity, and is an important source of greenhouse gas emissions from the industrial sector.

The Australian manufacturing sector has a relatively high rate of energy consumption because of the concentration on resource processing and other energy intensive industries. Production of aluminium, basic metal products, iron and steel, pulp and paper, chemicals and cement accounts for approximately 17% of all CO₂ emissions from fossil fuels in Australia.

Key approaches to reducing industry emissions include voluntary industry measures such as cooperative government-industry agreements and participation in international initiatives; demand management, energy audit, and cleaner production programs; promotion of environmental management; and revised taxation regimes.

Voluntary industry measures

It is recognised that governments cannot deliver effective greenhouse benefits without working in partnership with industry. The Commonwealth's Greenhouse Challenge Program (refer to box) is addressing the involvement of industry as part of the national greenhouse response.



The Greenhouse Challenge Program

The Greenhouse Challenge is a successful program of cooperative agreements between government and industry to reduce greenhouse gas emissions.

Since its launch in 1995, companies which collectively emit approximately 45% of Australia's industrial greenhouse emissions have joined the program. By November 1997, 100 agreements had been finalised, and more than 100 more companies and industry associations had lodged their formal Letter of Intent to participate and begun to develop their agreements.

Together the companies outside the electricity sector are projecting to reduce their forecast emissions by 21.5 Mt CO₂-e by the year 2000 to 111 Mt. About half of these companies will reduce their year 2000 emissions to stabilise at or below 1995 levels, despite growth in their businesses.

In addition, the electricity generators will be saving 3.4 Mt of emissions on their forecast growth by the year 2000, and the electricity distributors will be saving 0.5 Mt.

The Prime Minister's greenhouse package extends and expands the Greenhouse Challenge Program to allow an even greater uptake by industry. The number of large and medium-sized companies joining the program will increase to 500 by the year 2000, and to more than 1000 by 2005.

The Greenhouse Challenge will also be expanded to involve hundreds of smaller companies through the innovative 'Greenhouse Allies' program. This will enable companies linked by geography, business or other means to work jointly to reduce greenhouse gas emissions.

Participation in the program has been across all sectors. Agreements have been signed with companies in the mining, petroleum, chemicals, cement, energy generation and distribution, transport and commercial sectors. Some key results to date include:

Mining: The 13 mining companies currently on the program account for two-thirds of the emissions from the sector. Together they have committed to stabilising their emissions at 1995 levels by the year 2000.

Aluminium: Australian aluminium smelters are already very efficient, and in the period from 1990 to 1995 achieved a 14% reduction in emissions (largely due to a decline in perfluorocarbon emissions). The Australian aluminium industry has committed to further reduce emissions per tonne of production by 7% by 2000.

Cement: All five major cement companies have joined the program. They have committed to reduce their emissions in 2000 to below 1990 levels.

Pulp and Paper: Three of the five major companies in this sector have joined the program. Two of these companies will reduce their net greenhouse emissions in 2000 to below 1990 levels.

Commercial and Services: The 11 enterprises now participating in the program will reduce their total emissions in 2000 to below what they were in 1995.

The program is being expanded to encourage participation by smaller companies through sector-based initiatives. Strategies are under way with the textiles, hotels, hospitals and metals industries. In September the first four companies that joined the program in June 1996 provided their first annual progress reports. These companies have shown that they are well on track to meeting their initial commitments, and in many cases have identified further actions to reduce their emissions in 2000.

First 100 Greenhouse Challenge agreements

Advance Energy	Edison Mission	Rio Tinto Limited
AEEMA	energex (formerly South East Queensland Electricity Board)	Road Transport Forum
AGA (The Australian Gas Association)	Energy Brix Australia	SA Brewing Co. Pty Ltd (subsidiary of Lion Nathan)
AGL (The Australian Gas Light Company)	EnergyAustralia	SEICA (Sustainable Energy Industries Council of Australia Inc)
Ampol	ESAA	Shell Australia Limited
APPEA	Hazelwood Power	Smith and Nephew
ARCO Coal Aust Inc.	Honeywell	SOCOG (Sydney Organising Committee for the Olympic Games)
Association of Fluorocarbon Consumers & Manufacturers	Huntsman Chemical Co Aust.	Solahart Industries Pty Ltd
Australian Aluminium Council:	Hydro-Electric Corporation, Tasmania	South West Power
Alcoa Australia Ltd	ICI Australia Limited	Stanwell Corporation Limited
Capral Aluminium Ltd	Integral Energy	Tarong Energy Corporation Ltd
Comalco Limited	Johnson & Johnson Pacific	Tasmanian Transport Assoc.
Tomago Alum. Co. Pty Ltd	Kemcor Australia Pty Ltd	The Body Shop
Worsley Alumina Pty Ltd	Kimberley-Clark Australia Pty Limited	Toowoomba Foundry
Queensland Alumina Pty Ltd	Latrobe Valley Task Force	Tyco International
Nabalco Pty Ltd	Lend Lease Property Management Australia Ltd	United Energy Ltd
Australian Business	Logistics Management Association (Victoria)	Victorian Road Transport Association Inc.
Australian Chamber of Manufactures	Loy Yang Power	WBBEC (Wide Bay-Burnett Electricity Corporation)
Australian Coal Association	Macquarie Generation	Woodside Petroleum
Australian Cogeneration Assoc.	MEB (Mackay Electricity Corporation)	Wesfarmers CSBP Ltd
Australian Fleet Managers Association	McDonald's Australia	Western Mining Corporation Ltd
Australian Healthcare Assoc.	MIM Holdings Limited	Western Power Corporation
Australian Hotels Association	Minerals Council of Australia	Westpac
Australian Institute of Petroleum Ltd	MTIA	Yallourn Energy Pty Ltd
Australian Newsprint Mills	National Australia Bank	
Australian Paper	NatRoad	
BHP	North Limited	
BP Australia Ltd	NorthPower	
CAPELEC	NRG Gladstone Operating Services Pty Ltd	
Cement Industry Federation Ltd	NSW Road Transport Assoc.	
City of Newcastle	PACIA	
CS Energy	Pacific Power	
Cyprus Australia Coal Company	Parliament House Australia	
Delta Electricity	Pasminco Limited	
Department of the Environment	Peabody Resources Ltd	
D & P Haulage Pty Ltd	Pioneer International Ltd	
Eastern Energy Ltd	Power & Water Authority, NT	
Ecogen Energy	PPMFA	

Victoria is pursuing a similar cooperative approach to energy efficiency and greenhouse gas emissions reduction through the 'Energy Smart Companies' campaign, a corporate commitment program providing acknowledgments and rewards to participants. Improved energy efficiency is also pursued through industry waste and recycling agreements with the Victorian Environmental Protection Authority, accredited licensing, and environment improvement plans. In NSW, SEDA is implementing industry and commercial cooperative agreements to promote energy efficiency, renewables and cogeneration.



Draft National Strategy for Cleaner Production

This strategy will aim to establish a framework that provides industry with the incentive, the information and the capacity to improve its environmental performance in the design, production and delivery of goods and services to the community. 'Cleaner production' is a broad field, encompassing all aspects, stages and sectors in production processes, in particular energy efficiency.

Taxation arrangements

Since 1992, the Commonwealth Government's tax legislation has provided for substantial acceleration of depreciation deductions for plant and equipment, allowing older equipment to be replaced more quickly with cleaner, more energy efficient technology.

Energy information programs

A range of programs exist in Victoria, South Australia, Queensland and the Northern Territory to provide information and advice on energy efficiency to industry and commerce.

Residential, commercial and institutional

The residential and commercial sectors are diverse, containing numerous consumers requiring a wide range of energy services. Improvements in energy efficiency in the residential and commercial sectors are dependent on many factors; these include rates of new house and building construction and renovations. A number of examples in which improvements have been achieved were given under 'Energy and transformational industries'.

Energy performance codes and standards for domestic appliances and industrial equipment

A new measure contained in the Prime Minister's November 1997 announcement will reduce greenhouse gas emissions by improving the energy efficiency of appliances and equipment. It will enhance and extend existing energy efficiency programs. This measure involves the development of minimum energy performance standards for a greater range of new appliances and equipment, regulating or developing codes of practice to ensure their adoption and, where appropriate, labelling or rating appliances and equipment to help consumers in their selection.

Energy labelling for major domestic appliances has been in place in most Australian States for several years. As part of the current domestic response agenda, governments are also committed to the introduction of minimum energy performance standards for a limited number of domestic electrical appliances. These standards have been developed in consultation with the manufacturing industry, and will take full effect from October 1999.

Energy efficiency programs

Governments have agreed to implement a nationwide House Energy Rating Scheme (NatHERS), which will be coordinated to ensure consistency with State-based rating schemes. The new scheme will take account of factors that vary from region to region such as local climate and heating requirements.

A major new initiative under the Prime Minister's package is the instigation of a Residential Greenhouse Action Consortium. This will bring together the various levels of government and representatives from householders, builders, architects, financial institutions, energy utilities and planners in broadly based partnerships to develop integrated, consistent and effective strategies to address residential greenhouse gas emissions. Key components include:

- *expanding NatHERS by including a minimum energy performance requirement for new housing and extensions to improve energy efficiency;*
- *integrating approaches to promoting and financing energy efficient equipment and dwellings; and*
- *promoting energy efficiency in the housing industry.*

The Victorian Government's 'Energy Victoria' initiative is facilitating the adoption of cost-effective energy efficiency and renewable energy technologies in the residential, business and government

sectors. Activities include: Energy Smart Companies; Small Business Benchmarking; Government Energy Services; the Energy Information Centre; residential and small business 'Galaxy Awards' for five and six star rated appliances; and Community Awareness Programs.

The NSW and Victorian EPAs have also produced an interactive computer program to encourage householders to minimise greenhouse emissions by assessing emissions generated by their everyday activities and modeling options for their reduction.

Government operations

The Commonwealth Government has made a strong commitment to leading by example in ensuring that its own procurement practices and operations maximise energy efficiency. Departments and agencies are currently required to report annually against energy targets and on progress in improving energy efficiency. Similar programs are being implemented by State and Territory Governments.

As part of the new measures, the Commonwealth Government will demonstrate best practice within its own operations by: setting mandatory targets; using performance contracting; monitoring and reporting on performance; developing minimum energy performance standards for new and refurbished buildings, appliances and equipment; and using solar and other renewable energy technologies where relevant and cost-effective.

The SEDA 'Energy Smart Buildings in Government Program' aims to reduce energy consumption in NSW Government buildings by 15% by 2001 and 25% by 2005. Its 'Energy Star Office Equipment' program aims to halve the State's \$25 million energy bill from the use of office equipment.

Governments are also implementing an 'EcoOffice Scheme', which emphasises reducing and reusing resources in the workplace and also covers energy. When purchasing household electrical appliances, Commonwealth agencies must buy products with at least a four star rating where available.

Commercial buildings

A new approach has been taken to energy efficiency in commercial buildings with the circulation in early 1997 of a discussion paper to stakeholders following industry consultation. It is envisaged that measures agreed under the new approach will be introduced from 1998.

Under the November 1997 package of enhanced measures, the Commonwealth Government will work with the States, Territories and key industry stakeholders to develop voluntary minimum energy performance standards for new and substantially refurbished commercial buildings on the basis of energy efficiency benchmarks. If after twelve months the Government assesses that the voluntary approach is not achieving acceptable progress towards higher standards of energy efficiency, it will work with the States and industry to implement mandatory standards through amendment of the Building Code of Australia.

In some States, energy conservation plans are required for prescribed categories of buildings. The purpose of these plans is to assess the buildings' energy efficiency in order to promote the efficient use of energy and, where possible, to provide substitutes for non-renewable resources.

Local Government programs have also been introduced. For example, the Brunswick City Council operates a Community Buildings Energy Improvement Service to support energy auditing and retrofitting of community buildings.

Benchmarking energy efficiency

Reduced greenhouse gas emissions and increased economic competitiveness are outcomes of an energy efficient economy. Although reliable data are sparse recent studies suggest that, relative to other countries, Australia's energy efficiency performance on an industry by industry basis is mixed.

The Commonwealth Government is developing bases for benchmarking Australian performance in energy efficiency against available international data, and is participating in cooperative efforts to improve international comparative data. This work will be complemented by analyses, in specific sectors, of the



technical and economic options for improvement of Australian performance against these benchmarks.

The Prime Minister's November 1997 package contained a new measure on industry efficiency benchmarking and best practice. It will involve industry associations and government working together to identify the types, extent and patterns of energy use within sectors and the improvement potential for enterprises in particular sectors based on best practice, and working on strategies to implement best practice and to monitor progress. The benchmarks and best practice indicators will be provided by the Greenhouse Challenge Program to assist in formulating cooperative agreements.

2000 Olympics – World's largest solar powered residential development

The NSW Government, in partnership with SEDA, will develop the world's largest solar powered residential development at the Olympic Village Site in Sydney. Facilities for the 2000 Olympics are being designed and constructed as a showcase for new Australian energy technologies that can minimise greenhouse emissions. They will combine best practice in environmental management, energy efficiency and sustainable development.

Fugitive fuel emissions

Fugitive emissions of carbon dioxide can arise during the development of crude oil and gas resources. Relevant policies and measures deal collectively with carbon dioxide, methane and other hydrocarbon emissions and are described under the Methane section of this chapter.

Agriculture, land use change and forestry

In 1995, emissions from agriculture accounted for 18% of Australia's net greenhouse gas emissions. Forestry and pasture improvement comprise a net sink of around 28 Mt CO₂ equivalent. In contrast, in 1995 land clearing contributed about 85 Mt CO₂ equivalent. The land use change and forestry sector, through increasing and protecting vegetation cover, is an important means of enhancing Australia's greenhouse gas sink capacity.

Sustainable natural resource management is one of the key objectives of the Commonwealth Government. A well coordinated package of policies and actions aimed at achieving sustainable agriculture and land use practices and enhanced natural resource management in Australia has been in place for some time. A reduction in greenhouse gas emissions is one of the objectives of these sustainability policies. The increased impetus given to these initiatives through funding from the Natural Heritage Trust (see below) will assist in securing additional greenhouse gas benefits.

The Commonwealth Government is also committed to a major expansion of revegetation activities, increased plantation establishment rates, enhanced management and protection of existing vegetation, encouragement of minimum tillage, improved pasture management, and overall improvement of the management of natural resources by the users of these resources. These policies address a range of the greenhouse gas emission sources from the agricultural sector in Australia, and put measures in place to achieve a significant reduction in these emissions within the 'no regrets' framework.

Natural Heritage Trust

The centrepiece of the Commonwealth Government's effort is the \$1.25 billion Natural Heritage Trust. A major component, 'Bushcare: the National Vegetation Initiative', aims to expand revegetation activities and reverse the long term decline in the quality and extent of Australia's native vegetation by working with governments, industries and the community. The protection of native vegetation will also be pursued through the National System of Reserves (see box below for funding details).

The Trust will enable all governments, community groups and individual landholders and managers to take an integrated, long term approach to the conservation and sustainable management of Australia's land, water and biodiversity.

Natural Heritage Trust Projects and Programs

Projects will be funded under the categories of community grants, regional strategies, national partnerships and Commonwealth initiatives.

Funding allocation is as follows: Bushcare: the National Vegetation Initiative (\$366 million); National Landcare Program (\$259 million); and the Farm Forestry Program (\$20 million). Other elements that address vegetation protection include: Murray–Darling 2001 (\$163 million); National Rivercare Initiative (\$85 million); National Reserves System (\$80 million); and the National Wetlands Program (\$11 million).

Previous successful programs, such as ‘Save the Bush’ and ‘One Billion Trees’, have been incorporated under the Trust.

Bushcare: the National Vegetation Initiative

This initiative provides a tenfold increase in direct on-ground funding for vegetation programs and represents an historic turning point in Australia’s stewardship of its natural heritage. In addition to providing significant greenhouse benefits, it will conserve biodiversity and contribute to the ecologically sustainable management of natural resources.

Under the new measures announced in November 1997, companies or investors will be able to directly fund Bushcare revegetation programs and obtain recognition through the Greenhouse Challenge Program for the stored carbon reservoirs created. This will allow companies to offset emissions created by their activities elsewhere. Projects selected will have significant carbon sink potential and meet the range of other Bushcare objectives.

National Landcare Program

This program supports activities that contribute to the sustainable management of land, water and vegetation resources, in line with regional, State and national strategies. Emphasis is placed on providing assistance to communities to overcome impediments to achieving sustainable management, through a cooperative approach involving community groups, Local Governments, industry and State agencies.

The following Trust programs fund activities that revegetate river catchment areas:

National Rivercare Program

This program will assist sustainable management, rehabilitation and conservation of rivers outside the Murray–Darling Basin. Measures will focus on on-ground community restorative measures, larger scale projects addressing barriers to improved water quality, community education and monitoring, and a national biological river health assessment.

Murray–Darling 2001

The Murray–Darling 2001 project will significantly accelerate on-ground action to address natural resource management issues in the Murray–Darling Basin river system. The project aims to improve the health of key river systems; encourage ecologically and economically sustainable land use; restore riverbank land systems, wetlands and floodplains; and improve water quality.

Wetlands

The National Wetlands Program promotes the conservation and wise use of wetlands across Australia. The Program supports local projects to rehabilitate degraded wetlands and contribute to the overall health of Australia’s waterways.



Rangeland management

A Draft National Strategy for Rangeland Management has been developed for consideration by government to address the range of environmental, economic, social and cultural challenges in relation to the sustainable use and conservation of Australia's arid, semi-arid and tropical zones.

The principle of Ecologically Sustainable Development underlies the draft strategy, which has been developed to: examine existing and evolving strategies, policies and practices for sustainable rangelands use and management, including opportunities for alternative resource use; identify economic, social and ecological issues requiring a national approach for their resolution; identify gaps in the current policy framework and propose action to address them; and consider the roles and responsibilities of various levels of government and the community and opportunities for cooperation.

Recent research by the Bureau of Resource Sciences estimated that more than 300 Mt of organic carbon could potentially be stored through the rehabilitation of deteriorated pastures in the northern Australian rangelands over 30 years. A substantial portion of this may be achieved through changes in management practices, such as reductions in average stocking rates.

Forests

The sustainable management of forests can provide significant greenhouse benefits in addition to supporting many ecological processes. Key initiatives in this area include: the National Forest Policy Statement of 1992; Regional Forest Agreements; the Farm Forestry Program; 'Plantations for Australia - the 2020 Vision'; and the Wood and Paper Industry Strategy.

National Forest Policy Statement (NFPS)

The NFPS is the policy framework implemented by Australia to ensure the sustainable use and conservation of forests. It has been agreed by State, Territory and Commonwealth Governments.

The NFPS outlines agreed national goals relating to the future of public and private forests. It acknowledges the need to manage forests so as to maintain or increase their net carbon sink and storage capacity and to minimise the emission of greenhouse gases from forest activities. Two of the principal objectives of the NFPS are the maintenance of an extensive and permanent forest estate in Australia and the protection of nature conservation values in forests.

Plantations for Australia - the 2020 Vision

The Ministerial Council on Forestry, Fisheries and Aquaculture agreed in 1997 to a target of trebling the area of Australia's plantation estate by the year 2020. The Plantations 2020 Vision initiative comprises a series of measures designed to remove impediments to plantation establishment, establish a commercial plantations culture and improve information flows.

As part of the new package of measures, the Commonwealth Government has announced that it will fund key actions necessary to increase the current plantation establishment rate from 20 000 to 80 000 hectares per year. Activities include appointment of a national coordinator, development of a communication strategy, workshops, and a range of studies to assess land suitability and availability.

The Farm Forestry Program

The Farm Forestry Program (FFP) promotes the incorporation of commercial tree growing and management into farming systems for the purposes of wood and non-wood production, increased agricultural productivity and sustainable natural resource management.

Wood and Paper Industry Strategy 1995

This is a four-year Commonwealth initiative to promote value-adding to our forest resources by developing a diverse, internationally competitive wood and paper industry based on ecologically

sustainable management practices. It is a key element in the Commonwealth Government's integration of industry and conservation objectives for Australian native forests and plantations. The Strategy focuses on encouraging investment, value adding and jobs growth.

National Forest Inventory

This inventory has produced comprehensive documentation on species extent and density, thereby underpinning the forest components of the Greenhouse Gas Inventory. The program has also compiled detailed, spatially based, information on the extent and rate of growth of the plantation estate which at the end of 1994 covered more than one million hectares (approximately 10 500 square kilometres).

Regional Forest Agreements (RFAs)

The Commonwealth and State Governments are currently developing regional agreements to create secure reserve systems to protect native forests with high conservation values and to provide for the long term ecologically sustainable management of Australia's forests. These agreements will also help to conserve the sink and storage capacity of Australia's native forests.

Other State forestry initiatives

The NSW Government has a commitment to establish 35 000 hectares of native hardwood and introduced softwood species on plantations and both public and private land over the period 1995/96 to 1998/99. The plantation project involves an expanded research and development program costing about \$1 million per year, a major component of which is a genetic improvement program to increase growth and yield from the plantations. State Forests' nurseries have been expanded and are also supplying stock for farm forestry programs.

The Victorian Government is committed to harvesting publicly owned forests on a sustainable yield basis and is actively encouraging private plantation development in accordance with its commitment to trebling the State's plantation reserves under the Plantations 2020 Vision initiative. Victoria is also working to promote a viable and competitive timber industry which maximises carbon storage in forest products. The adequacy of reserves for conserving Victoria's biodiversity in relation to the potential threat of climate change is under continuous review.

National carbon accounting system for land-based sources and sinks

A new measure will establish a national carbon accounting system. A consolidated package will provide the comprehensive framework and scientific services necessary to account for Australia's emission reduction and sink enhancement programs to an internationally credible standard. Data on Australia's carbon stocks will be verified by satellite monitoring and audited by on-ground sampling procedures. This form of carbon accounting, which has been adopted by the IPCC, will enable Australia to benefit from the full 'carbon value' of its sink development initiatives such as Plantations 2020 Vision and Bush for Greenhouse.

Other greenhouse gas sink enhancement activities

The South Australian Government has planted 750 000 trees to counter greenhouse gas emissions from public transport. Revegetation of roadsides is also being carried out to counter emissions from road transport.

The Commonwealth Government is also developing a carbon sink offsets program, 'Bush for Greenhouse', to enable industry to invest in the establishment of vegetation cover.

Victoria's 'Greenfleet' is an environmental organisation initiative which aims to offset vehicle emissions through revegetation. Annual contributions from companies with vehicle fleets and other motorists finance tree planting programs in coordination with other private, community, State and Commonwealth tree planting programs operating in Victoria.



In the Greenhouse Challenge Program (see box), companies are allowed credits in their emission inventories for activities that they own or control which actively absorb carbon from the atmosphere. Companies may also include in their agreements activities that produce sinks for CO₂ to which they contribute, but do not own or control, as 'influence' actions. Such actions are acknowledged in their agreements, but do not form part of the companies' core emissions inventories. Around one-third of companies have included vegetation-related carbon sinks in their finalised agreements.

The Greenhouse Challenge Office has recently contracted an international consortium to develop a 'Sinks Workbook' on methodologies that can be used to quantify sequestration of carbon achieved through agroforestry, plantation forestry, and environmental and Landcare plantings.

Land clearing controls

While it has no constitutional jurisdiction in this area, the Commonwealth Government is working with the States and Territories to develop and implement sustainable management regimes for native vegetation use and protection, including a reduction in the greenhouse gas emissions from land use change. The Commonwealth Government is currently pursuing action on native vegetation clearance through negotiations with the States and Territories on the revision of the National Greenhouse Strategy and through the Council for Sustainable Vegetation Management, the Vegetation Coordinating Committee and the Natural Heritage Trust Partnership Agreement negotiation. The ultimate goal is to develop national guidelines for the management of native vegetation. Several jurisdictions have mechanisms in place to address vegetation clearance:

- New South Wales has controls in the most sensitive areas of the State. In areas not subject to legislative constraints, an increasing responsibility and awareness concerning the need to preserve native vegetation is developing among landholders as a consequence of Landcare and total catchment management initiatives.
- In Victoria, controls on the clearance of native vegetation are in place. Continuing research and monitoring of clearance through the use of remote sensing techniques is being pursued.
- In Queensland, local guidelines on tree clearing on leasehold land are nearing completion. Guidelines aim to enhance long term productivity while also conserving and protecting biodiversity and ecological processes or systems.
- In Western Australia, new measures were introduced by the Government in 1995 to improve the protection and management of remnant vegetation on private agricultural land. These include restrictions on land clearing and financial incentives. The Western Australian Government also established a Memorandum of Understanding between statutory decision making authorities by which land clearing may be averted.
- Broadscale clearance of vegetation in South Australia is prohibited and large areas of native vegetation are protected. Vegetation on private land is protected by heritage agreements between landholders and the State Government.
- Tasmania has introduced new legislation which regulates vegetation clearance through planning schemes and a requirement for permits.

Uncertainties

Large quantitative uncertainties exist in current estimates of the extent of emissions associated with land use change. The Bureau of Resource Sciences is currently engaged in a collaborative Commonwealth-State project to monitor agricultural land cover change over the period 1990 to 95 using remotely sensed data. This will produce more accurate figures for these emissions. The results of the project, which will be available in 1998, will be used together with available soil carbon information and biomass data to refine estimates of the emissions associated with removal of above-ground, and disturbance of below-ground, carbon pools.

METHANE EMISSIONS

Methane emissions accounted for around 23% of Australia's total greenhouse gas emissions in 1995. Sources include: gas drilling, venting and transmission; coal mining; landfills and animal wastes (particularly from intensive livestock production); rice paddies; the burning of vegetation; and the digestive processes of ruminant animals.

Policies and measures adopted and implemented in Australia are focused towards reducing and capturing methane emissions from these sources.

Waste management

Landfill gas

In many of the State capitals, electricity is now generated using methane gas from municipal landfills. Options for the collection and conversion of methane from landfill sites as an alternative energy source are being encouraged by State Governments and implemented by some Local Governments around Australia. One Australian independent power company has constructed and operates power generation plants producing more than 160 megawatts at 15 coal mines and landfills around Australia. In South Australia, methane gas from landfills is being extracted and used to generate 29 megawatts of electricity, which is used in the grid. In Victoria, a number of Melbourne landfill operators are generating in excess of 26 megawatts of electricity from landfill gas.

Waste Minimisation and Recycling Strategy

Under the Waste Minimisation and Recycling Strategy adopted by the Australian and New Zealand Environmental and Conservation Council (ANZECC), the Commonwealth, States and Territories have agreed to reduce the amount of waste going to landfill by the year 2000 by 50% compared with 1990 per capita levels. Waste management is a State, Territory or Local Government responsibility, and most jurisdictions have waste minimisation and re-use strategies.

Green and Organic Waste Management Strategy

Implementation of the Green and Organic Waste Management Strategy, which was agreed by ANZECC in 1996 subject to the development of markets for recycled organic products, is fundamental to the success of action to reduce methane emissions from landfill.

The NSW Government's waste management strategy focuses on waste avoidance, followed by reuse, recycling and reprocessing, with waste disposal as a last resort. This commitment, and a strategy to fulfil it, were established by the Waste Minimisation and Management Act 1995. Action has included: the targeting of green waste, building and demolition waste, and commercial and industrial waste; development of binding industry Waste Reduction Plans; government purchasing policies favouring waste reduction and recycling; the implementation of a regional waste management system; and the formation of a government advisory body, the State Waste Advisory Council.

The NSW Government has also established a Waste Planning and Management Fund to ensure effective implementation of the strategy. Some \$32.5 million has been committed to this for the first three years, with a further \$24.2 million indicated for the fourth and fifth years subject to a review in the third year.

The NSW Government's Waste Reduction and Purchasing Policy will indirectly result in a reduction in the production of methane in landfill sites due to the removal of organic material from the waste stream.



The Victorian Government has committed more than \$10 million in funding over three years towards the establishment of resource recovery and waste management facilities, with particular support for food and green organics recovery programs.

Local Government initiatives

A number of Local Government authorities have formulated community education programs on kerbside collection, household recycling and mulching schemes. A community local council composting-training pilot program is nearing completion.

A national approach involving all governments is essential to effective waste minimisation programs. Further options being considered include:

- voluntary industry agreements aimed at meeting existing agreed 50% reduction targets in all waste streams; and
- strategies to reduce waste and improve recycling in all areas of government operations. This new initiative will seek to encourage the development of waste minimisation agreements with a wide range of Commonwealth Government organisations.

In one example, Newcastle City Council will save more than 140 000 tonnes of CO₂ equivalent emissions through tapping methane from its recently closed landfill and ensuring its new landfill also has this capacity.

Agriculture

Sustainable agriculture is a major focus of government policy in Australia at both the Commonwealth and State levels. A positive greenhouse gas outcome is one of the objectives of sustainable agricultural policies, including actions that will assist in the reduction of methane emissions. These policies incorporate measures to encourage the uptake of sustainable land management practices such as improved animal husbandry. Improving manure management will reduce the levels of methane emissions from agricultural production.

Waste management in agriculture

Several strategies have been developed to reduce the amount of waste arising from agriculture and natural resource use. Programs to reduce the amounts of agricultural wastes, such as dairy effluent, entering waterways are under way in most States. These cover areas such as reducing effluent production, reuse and recycling. Work is being undertaken to improve the efficiency of fertiliser spreading and handling to reduce the amount entering waterways; this includes the development of a fertiliser spreading accreditation program and codes of conduct. Extension strategies are in place to enhance the capacity of intensive livestock holdings to implement new animal waste processing systems.

Better animal manure management is also being pursued to reduce the quantities of methane produced by its decomposition and to encourage its use as fertiliser.

Increased efficiency of production of animal products will reduce methane emissions from animals - especially sheep and cattle - and the whole agricultural system.

CSIRO has patented an anti-methanogen feed additive which suppresses methane emissions by up to 100%. Drawbacks are that it results in only marginal production gains and has to be fed daily.

CSIRO has also patented a methanogen vaccine which is achieving an 18% reduction in emissions with some significant production gains, and is suitable for both sheep and cattle. Further research and development into the technical feasibility of these technologies, and work on their commercialisation, is being carried out to determine whether it is practicable to apply them to reduce Australia's methane emissions from ruminant animals.

The Prime Minister's recent announcement includes funding to promote this vaccine.

Fugitive emissions

Natural gas pipelines

Leakage of methane from gas pipelines is being reduced by rehabilitation of low pressure gas reticulation pipelines. Unaccounted-for gas as a percentage of gas issued has continued to decrease, with Australian gas utilities reporting a 40% improvement since 1991/92.

Oil and gas production

Fugitive emissions from oil and gas exploration and production are regulated under Commonwealth petroleum legislation offshore, and State and Territory petroleum and/or environmental legislation onshore. Fugitive emissions occurring during refinery operations are regulated under State and Territory environmental legislation. In Victoria in particular, emissions are covered by the State Environment Protection Policy (Air). The industry is required to comply with legislation covering leak detection and repair, monitoring and flaring, and works approval and licensing requirements.

New technology has reduced methane emissions during liquefaction of natural gas. Emissions from the North West Shelf Project were 10% lower in 1995 than with the original plant design, and there is potential for a further 19% reduction.

The Australian Petroleum Production and Exploration Association and the Australian Institute of Petroleum, which represents the petroleum industry, have signed agreements under the Greenhouse Challenge Program to reduce the greenhouse gas emissions of their respective industries.

Industry

As part of the Greenhouse Challenge Program of cooperative agreements between industry and government, industry has introduced various voluntary measures to reduce methane emissions. These are described below.

Coal bed methane

BHP's Steel Collieries Division will convert coal seam methane into electricity at two mines in the South Sydney Basin and one in Queensland (see box).

Methane emission reductions by Greenhouse Challenge participants

- BHP is Australia's largest resource company and an international producer of minerals, steel and petroleum. The capture of methane at two coal mines to generate electricity or pipe to the natural gas grid will save over 6.2 Mt of CO₂ equivalent emissions per annum.
- Newcastle City Council will capture methane from two landfill sites and generate electricity, saving over 140 000 tonnes of CO₂ equivalent emissions per year.
- The Australian Petroleum Production and Exploration Association (APPEA) has developed and implemented an array of Action Plans by which its members have saved 3.6 Mt CO₂ equivalent over the period 1990–1995 and will save a further 4.9 Mt by 2003. The Action Plans involve measures such as improving plant fuel efficiency and reducing flaring, cold vents and fugitive emissions.



NITROUS OXIDE AND OTHER GASES

Nitrous oxide and perfluorocarbons (PFCs) make up a relatively small part of Australia's greenhouse gas emissions, about 6% in 1995.

Agriculture and land use sector

Anthropogenic sources of nitrous oxide emissions include biomass burning, land clearing, leguminous pastures, nitrogen fertilised crops, animal manure and urine, and fossil fuels. The addition of nitrate and ammonium fertilisers to soils is another source of N_2O closely associated with soil processes and agricultural practices.

By world standards, Australian use of nitrogenous fertilisers on agricultural land is very low. Although there is little scope for lowering usage, there is scope to reduce the associated N_2O emissions through improved fertiliser application and handling practices. Work is being undertaken in cooperation with industry to develop codes of practice and accreditation processes to improve the efficiency and reduce the improper application of fertiliser in Australian agriculture.

N_2O can also be emitted with the decomposition of leguminous pastures. However, the use of these species in annual and perennial pastures is generally highly desirable as it reduces the need for artificial fertilisers, and there is little scope for reducing the use of leguminous pasture species. Improved efficiency in nitrogen uptake from legume nitrogen and nitrogen-based chemical fertilisers reduces the need to replace nutrients lost from the soil with chemical fertilisers. These fertilisers raise greenhouse gas emissions through energy-intensive manufacture and release of N_2O when in use.

PERFLUOROCARBON EMISSIONS

Tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are strong greenhouse gases which are formed under certain transient operating conditions, called the anode effect, in the production of aluminium. Emissions of these perfluorocarbons are being addressed by reduction of the amount of time per day per cell when the anode effect occurs.

The Australian aluminium industry has achieved major reductions in the anode effect - to less than one-third of 1990 levels (see 'The Greenhouse Challenge Program' box).

Australian smelter operators are continuing to work on process improvements. The rate of improvement will reduce as the factors that determine the anode effect and energy efficiency approach practical limits for each smelter.

HYDROFLUOROCARBON EMISSIONS

Hydrofluorocarbons (HFCs) were developed as replacement refrigerants for chlorofluorocarbons (CFCs). HFCs contain no chlorine and therefore do not affect the ozone layer. However, they have a Global Warming Potential.

Given the growing use of HFCs, steps have been taken by industry to minimise their impact by reducing emissions to the atmosphere.

In the early 1990s Codes of Good Practice were developed and implemented by all sectors of the air conditioning and refrigeration industry to minimise the emission of ozone depleting substances (CFCs and HCFCs), including through practices such as recovery and recycling. The refrigeration and air conditioning industry has recently revised these Codes to include HFCs.

MONITORING AND REPORTING

A significant element of Australia's National Greenhouse Strategy relates to mechanisms for effective monitoring and reporting of the policies and measures contained in the Strategy.

These include:

- preparation of periodic (biennial) reports on progress in implementation - these reports include assessments of the progress and implementation status of policies and measures and their effectiveness in addressing the Strategy's goals to limit greenhouse gas emissions and protect and enhance greenhouse sinks;
- the annual compilation of the National Greenhouse Gas Inventory (see Chapter 3); and
- development of projections of greenhouse gas emissions as an integral component of strategic policy formulation (see Chapter 5).

Performance indicators are also employed to contribute to assessments of the effectiveness of the Strategy.

An initial set of primary indicators at the 'macro' and 'sectoral' levels has been developed and is presented in the box below. The final set of performance indicators, including 'secondary' and 'diagnostic' indicators, will be developed by June 1998 to complement the 'macro' and 'sectoral' indicators.

Macro and Sectoral Indicators

MACRO INDICATORS

- Total emissions (CO₂ equivalents)
- Emissions per unit of economic welfare/performance
- Emissions per capita

SECTORAL INDICATORS

Energy

Energy supply

- Total emissions from each sector
- Emissions per unit of gross product
- Energy emissions per capita
- Emissions from energy delivered by fuel type
- Emissions from energy delivered per unit of energy used

Household energy

Industrial and commercial energy

Transport

- Emissions from household energy per capita
- Emissions per unit of energy delivered
- Emissions per passenger-kilometre - total and by mode
- Emissions per freight tonne-kilometre - total and by mode
- Emissions per kilometre travelled in urban areas by mode

Industry process emissions

Agriculture

- Emissions from the aluminium industry
- Sheep methane equivalents per animal
- N₂O emissions index

Natural environment

Waste

- CO₂ from land use change (NGGI methodology)
- Methane emissions from landfill per capita



These tables do not include the Prime Minister's package of strengthened greenhouse measures announced on 20 November 1997.

Table 4.1: Summary of policies and measures: CO₂

Policy/measure	Type of instrument	Objective	Sector	Status	Estimate of mitigation Impact (Mt CO ₂)				Indication of progress
					2000	2005	2010	2020	
CROSS SECTORAL									
Information programs	Information	Energy efficiency	Cross sectoral	Implemented	0.1	0.0	0.0	0.0	Web site operating
ENERGY SUPPLY									
Energy micro-reform	Reform of market rules disaggregation of elec/gas utilities	Efficiency in elect supply	Electricity generation	Initiated	0.0	9.0	14.0	20.0	Competitive electricity market started 1997, gas market by 1999
NSW Electricity Act	Legislation	Efficiency in elect supply	Energy supply	Implemented	2.0	2.0	2.1	2.0	Some new pricing schemes operating
Renewables programs NSW SEDA	Market stimulation	Diversify electricity supply	Energy supply	Initiated	0.5	0.7	0.4	0.1	A\$39 million allocated 1996 to 99
Other	Various	Various	Energy supply	Mostly initiated	0.6	1.3	0.0	0.0	
CRC on renewable energy	Research program	Develop renewable technologies	Energy supply	Implemented	0.0	0.5	1.0	1.0	Budget A\$64 million over 7 years
TRANSPORT & URBAN PLANNING									
Fuel economy targets	Fuel economy targets	Liquid fuel conservation	Transport	Implemented	1.1	0.1	0.1	0.1	Some fall in national average fuel consumption
Travel demand measures etc.	Programs, initiatives	Liquid fuel conservation	Urban planning	Implemented	1.0	0.6	0.4	0.3	Publications on best practice in urban design
INDUSTRY (ENERGY USE)									
Greenhouse Challenge agreements	Voluntary industry	Emissions abatement	Industry	Implemented	6.0	8.0	9.1	10.1	50% of all industrial emitters involved
Energy efficiency (SEDA & NEEP)	Programs	Energy efficiency	Industry	Implemented	0.9	1.2	1.4	0.4	SEDA A\$39 million over 3 years. National energy efficiency program A\$1.9 million per annum
RESIDENTIAL (ENERGY USE)									
Appliance performance standards and labelling	Programs	Energy efficiency	Residential	Implemented	2.3	1.2	1.4	1.5	Labelling programs being upgraded
COMMERCIAL & INSTITUTIONAL (ENERGY USE)									
Energy efficiency, standards and equipment labelling	Programs	Energy efficiency	Commercial	Implemented	0.6	0.4	0.4	0.3	Technical and economic assessments completed
AGRICULTURE, LAND-USE CHANGE & FORESTRY									
Rangelands rehabilitation Trust	Landcare and extension activities of sustainable	improved implementation land management practices	Governments and community	Underway	2.1	2.3	2.3	2.3	Included in Natural Heritage A\$1.25 billion over 5 years
Tree planting programs inc. agroforestry	Government/industry programs	Rehabilitation of native vegetation and establishment of new plantations	Governments and community	Underway	3.4	4.5	4.8	5.1	Plantings in progress (including first stage of National Vegetation Initiative), already >A\$200m by many stakeholders. (Anticipate private sector investment of \$3 billion by 2020)
TOTALS					20.6	31.9	37.3	43.2	

NOTE: These figures exclude the effect of rebound. However rebound effect has been taken into account in deriving overall energy sector projections.

Table 4.2: Summary of policies and measures: CH₄

Policy/measure Indication of progress	Type of instrument	Objective	Sector	Status	Estimate of mitigation impact (GgCH ₄)				
					2000	2005	2010	2020	
WASTE MANAGEMENT									
Methane capture & waste minimisation	Statutory guidance	Sustainable waste management, emission abatement	Cross sect	Implemented	112	217	264	388	A number of landfill gas and waste minimisation projects operational
AGRICULTURE									
Reduced methane emissions from animal waste	Promotion, education	Environmental, emission abatement	Agriculture	Ongoing	1	1	3	6	Improved practices in demonstration for pigs and cattle feedlots
Rumen modifiers	Research, commercialisation promotion	Improved productivity, emission abatement	Agriculture	Development phase proceeding	0	108	182	306	Technologies patented
Reduced residue burning	Research education	Soil sustainability Emission abatement	Agriculture	Ongoing	2	2	3	3	Extension programs in place
FUGITIVE FUEL EMISSIONS									
Reduced leakage from gas mains	Industry initiative	Emission abatement, environmental, safety	Gas industry	Ongoing	5	9	14	23	Major programs run by utilities for a number of years
Reduced emissions from LNG and petroleum processing	Voluntary industry actions	Emission abatement	Petroleum industry	Ongoing	20 ¹	20	20	20	Agreements signed
Coal seam recovery	Voluntary industry agreements	Emission abatement	Mining	Ongoing	289	318	349	410	Agreements signed
TOTALS					429	675	835	1156	

1. Estimates of mitigation impact have been averaged because short term forecasts exhibit some variance from year to year



Table 4.3: Summary of policies and measures: N₂O

Policy/measure	Type of instrument	Objective	Sector	Status	Estimate of mitigation impact (GgN ₂ O)				Indication of progress
					2000	2005	2010	2020	
AGRICULTURE & LAND-USE CHANGE									
Reduced residue burning	Research, extension	Improve soils reduce emissions	Agriculture	Ongoing	0.05	0.07	0.08	0.1	Extension programs in place
Nitrification inhibitor	Research	Improve nitrogen take-up	Agriculture	Ongoing	0.05	0.09	0.17	0.26	Commercialisation phase reached
Reduced fertiliser use extension,	Research, fertiliser education	Improve application	Agriculture	Ongoing	0.38	0.6	1.07	2.35	Extension programs in place
TOTAL					0.48	0.76	1.32	2.71	

Table 4.4: Summary of policies and measures: Other gases and precursors - perfluorocarbons (PFCs)

Policy/measure of progress	Type of instrument	Objective	Sector	Status	Estimate of mitigation impact (GgCO ₂ -e)				Indication
					2000	2005	2010	2020	
INDUSTRY									
Reduction in PFC emissions by aluminium industry under Greenhouse Challenge Program	Voluntary industry agreements	Emission abatement	Aluminium industry	Ongoing	273	176	200	262	Large emission reductions being achieved (>3Mt CO ₂ -e in 1995)

Projections

INTRODUCTION

The development of projections of greenhouse gas emissions is integral to policy formulation in relation to Australia's climate change strategic agenda.

This chapter provides projections of greenhouse gas emissions for individual sectors of the Australian economy with a focus on the year 2010. The process of compiling the projections included extensive consultation across Government, reports from a number of consultants, and preliminary stakeholder involvement. The quantitative projections that were produced include the effects of measures in place in mid-1997 to reduce emissions.

As part of the ongoing enhancement of the range and effectiveness of policies and measures, the Prime Minister announced a Commonwealth package of strengthened greenhouse measures on 20 November 1997. The projections described in this chapter do not include those announced in the Prime Minister's package. The new package will reduce Australia's net emissions growth from 28% to 18% (excluding land use change) or some 39 Mt by 2010 (from 494 Mt to 455 Mt).

SUMMARY OF RESULTS

Emissions from the Energy Sector (which includes the Transport Sector but excludes Fugitive Fuel emissions) accounted for more than half of total emissions in 1990, and are expected to grow by 40% (106 Mt CO₂-e) between 1990 and 2010.

These projections reflect assumptions of continuing growth in GDP, in minerals processing, and in transport. They also incorporate the main measures expected to reduce emissions - micro-economic reform in the Energy Sector and the Greenhouse Challenge Program. When combined with other measures, these are expected to reduce emissions in 2010 by 22 Mt compared with the levels they would otherwise have reached. (That is, without these measures emissions could grow by 128 Mt between 1990 and 2010.)

The overall picture in the Energy Sector is one of continuing growth in emissions and an increasing share of Australia's total greenhouse emissions.

Agriculture accounted for about one-fifth of total national emissions in 1990. Emissions from this Sector are projected to grow by 7% (6 Mt) from 1990 to 2010.

The Forestry Subsector provides a sink, contributing about 5% (23 Mt) to national net emissions in 1990. Plantation expansion and revegetation activities are projected to increase this sink by 8 Mt between 1990 and 2010.

Fugitive fuel emissions, waste emissions and non-energy emissions from industrial processes together accounted for about 10% of total national emissions in 1990. They are expected to fall slightly, then exceed their 1990 levels by 11% in 2010.

Inventory data show that land clearing - primarily for cropping and pastures - accounted for about one-quarter of total national emissions in 1990, with this proportion declining to about one-sixth in

1995. The uncertainties in estimating emissions in the Land Use Change Subsector, for both the Inventory and projections, exceed those for any other sector.

Historical land clearing data were mostly inferred through modelling, but analysis of satellite imagery is beginning to confirm that figures used in the National Greenhouse Gas Inventory on recent land clearing rates are reasonably sound. There are uncertainties in estimating the emissions per unit of area of land cleared, especially for the carbon that is released over many years from soils. As reported in Chapter 3, considerable effort is being invested by Australia in strengthening the methodology and data inputs used to determine emissions due to land use change.

Because of the current uncertainties in land clearing data, projections of future emissions from this sector are not presented at this stage.

Including all sources and sinks except land clearing emissions, and allowing for the effects of current measures, Australia's total emissions are expected to increase by 28% (110 Mt CO₂-e) between 1990 and 2010. In the absence of measures to reduce emissions of greenhouse gases, Australia's emissions would be approximately 552 Mt CO₂-e in 2010, a 43% increase from 1990 levels.

PROJECTIONS METHODOLOGY

The approaches adopted in compiling projections for the various sectors followed a common general framework, with minor variations from sector to sector.

- A number of assumptions were made relating to expected trends in Australia and in the global economy. To ensure consistency across sectors:
 - common parameters were adopted wherever feasible - for example, population growth;
 - GDP growth was common to all sectors except where modelling imposed constraints, as in the Energy Sector.
- Projections were first made of activity or input data such as sectoral growth, electricity generated, livestock numbers, area of land cleared or quantity of coal exported:
 - generally some form of computerised general equilibrium or econometric model was used to derive these projected activity estimates;
 - these activity data were then converted into emissions or sinks projections, in accordance with the Australian National Greenhouse Gas Inventory methodology developed in accordance with IPCC Inventory Guidelines.
- An assessment was made of the impacts of current greenhouse response measures in reducing future emissions.
- For each sector, three scenarios of future emissions were analysed - a 'best estimate', a 'high estimate' and a 'low estimate'. Only the 'best estimates' are presented in this chapter.

ASSUMPTIONS

Baselines were calculated to estimate emission growth in the absence of policies and measures to reduce growth.

In the Energy Sector, baseline estimates were developed using four different estimation approaches - three general equilibrium models and one survey-based bottom-up approach. Assumptions for energy prices and the rate of autonomous energy efficiency improvement were standardised. However, as it was difficult to gain consensus between experts on future GDP growth, the best estimates were left to each modeller to specify. The resulting average projected GDP growth for Australia in the period 1995 to 2010 was 3.7%. The four estimates for the period ranged from 3.4% to 4.0%.

Account was taken of the 'rebound effect' in assessing the impact of existing energy measures. Rebound is the propensity for income from financial savings, gained from energy efficiency measures, to flow back into economic activity, thereby lifting energy consumption and offsetting some of the original energy saving. It was generally assumed that the rebound effect was 10% (the share of energy consumption in GDP).

Table 5.1. Summary of key variables and assumptions in the projections analysis (mid-range 'best' assumptions)

	1995	2000	2005	2010	2020
World coal prices (US\$/tonne)	Real coal prices unchanged 1995-2020				
World oil prices (US\$/billion barrels)	Oil and gas prices rising steadily by 1.2% per annum, to be 20% higher than 1995 by 2020				
Domestic energy prices (by fuel type and for electricity) for different relevant sectors (eg. residential, commercial and institutional, industry, transport)	Derived from world oil, gas and coal prices				
GDP (domestic currency)		3-4.4	2.7-3.4	2.3-3.1	1.7-2.9
annual % growth in 5 year period					
Industry, Waste:	2.64	2.64	2.29	2.29	1.95
% growth per annum per capita					
GNP Agriculture: % growth per annum	3.1	3.5	3.5	3.5	2.1
Population (millions) % growth	0.91	0.91	0.91	0.91	0.91
Autonomous Energy Efficiency Improvement across Energy Sector in Australia (AEEI)	Pure technological advance (ie. excluding structural changes and fuel switching) to improve at 0.8% per annum 1995-2020				
New vehicle efficiency (by vehicle type) (litres/100 kilometres)	Subsumed into AEEI assumption above				
Average vehicle kilometres travelled	Not available				
Primary energy demand (Petajoules)	Not available				
Index of manufacturing production (1990 = 100)	Not available				
Index of industrial production (1990 = 100)	Not available				
Rate of growth of industrial production % per annum	Not available				
Alumina	3.9	3.9	3.9	3.9	3.9
Aluminium	6.2	6.2	3.0	3.0	3.0
Cement	1.9	1.9	1.9	1.9	1.9
Clinker	1.0	1.0	1.0	1.0	1.0
Quicklime (growth above 1990 levels)		60% by 2000			100% by 2020
Crude steel	1.8	1.8	1.8	1.8	1.8

The Agriculture Sector projection assumes Gross National Product (GNP) growth of 3.4% on average from 1996 to 2002, then 3.5% from 2003 to 2010 and 2.1% from 2011 to 2020. In waste and industrial processes, GDP per capita growth rates of 2.64% from 1990 to 2000, 2.29% from 2000 to 2010 and 1.95% from 2010 to 2020 were assumed for the 'best estimate' scenario.

The effects of differing assumptions for GDP vary across sectors. Changes in GDP have significant effects on emissions in the Energy Sector, with emissions declining by around 0.8% for every 1% decline in cumulative GDP growth.

In the Agriculture Sector, Australian GDP growth has very little effect because the bulk of Australia's agricultural produce is exported. Consequently, estimates of exports to overseas markets are the major factor in projected activity levels and, therefore, emissions. There is no statistical relationship between GDP and activity in the Forest Sector. On the other hand, GDP growth is the major influence in the Industrial Processes Sector, and it has some influence on waste emissions.

The other major cross-sectoral variable considered was population growth, which has a significant influence on emissions from waste and some influence in forestry, industrial processes and agriculture. In energy, the GDP assumption was considered to capture the influence of population growth and, as already discussed, this varied between estimation approaches.

High (1.06%), best (0.91%) and low (0.85%) estimates of population growth, as provided by the Australian Bureau of Statistics, were used in different scenarios.

UNCERTAINTIES

Emissions projections are inherently uncertain. They involve judgements about the long term 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 any alternative set of assumptions concerning the future will yield a different result.

This is the first attempt at projecting emissions for all sectors of the Australian economy over an appreciable length of time, and so represents an early stage in the development of methodologies for emissions projections. Confidence in projections decreases as the time horizon extends, so these projections focus on 2010. Projections beyond 2010 should be interpreted as illustrative.

Uncertainties also arise from the data inputs to both the projections and the National Greenhouse Gas Inventory. Key areas of uncertainty are identified in each sector below.

To mitigate the methodological and input data uncertainties inherent in deriving projections, a conservative approach was adopted in the application of analytical methods and interpretation of results. No projections for land clearing have been included, pending improvements in the estimation of emissions and the development of projection models in this area.

PROJECTED EMISSIONS BY SECTOR

Energy

Scope of sector

The Energy Sector covers transport and non-transport energy, excluding fugitive fuel emissions. Both areas of energy use are subject to the same main set of assumptions. Difficulties were experienced in separately modelling transport and non-transport energy, so they were combined for this analysis.

This sector was responsible for more than half of Australia's greenhouse gas emissions in 1990, and for nearly all of the growth in emissions between 1990 and 1995. This was due to the large size of the sector, and its above average growth. According to the latest National Greenhouse Gas Inventory, in 1995 CO₂ emissions from the Energy Sector were 8% above 1990 levels. Over time, the Energy Sector will produce an increasingly large share of emissions.

Non-transport energy covers about 80% of energy emissions, and includes electricity generation and other fuel combustion activities to produce energy for commercial, residential and industrial use. Transport Sector emissions are dominated by road transport, both passenger and freight. About 98% of greenhouse gas emissions from the Energy Sector are CO₂.

Factors influencing Energy Sector emissions

Energy Sector emissions are a function of four key factors in the economy:

- the size of the economy overall, generally measured by GDP;

- the structure of the economy (eg. whether energy intensive sectors are growing or shrinking in proportion to the overall output);
- the efficiency with which energy is used in the economy; and
- the greenhouse intensity of energy supplied, which is a function largely of fuel mix (eg. coal produces high levels of greenhouse gas emissions per unit of energy, gas produces less, and renewable energy produces much less).

Projections are characterised by continuing growth in GDP, improved energy efficiency performance, and an ongoing substitution of natural gas for coal and oil in non-transport energy uses. In terms of economic structure the picture is less clear, though continued strong growth in the minerals processing sector, transport and services is expected. Emissions growth is faster in the Transport Sector than in non-transport energy because of the rapid growth of intra-urban freight using light trucks and aircraft, and little switching of fuel sources.

Analytic approach followed

Projections for the Stationary Energy and Transport Sectors are based on the results of three independent economic models (G-Cubed, MEGABARE and MONASH), the Fuel and Electricity Survey of Australian industry by the Australian Bureau of Agricultural and Resource Economics, and other analyses by government and private sector experts.

The economic models rely on assumed parameters about key driving factors, such as GDP growth rates, fuel prices and rates of improvement in technical energy efficiency. Data derived from a survey of industry, as well as expert judgement and consultation, have been used to support these results.

Baseline projections

Emissions from the Energy Sector were estimated to grow by 48% in the absence of measures, to 396 Mt CO₂-e in 2010.

Effects of policies already in place

The main measures in place that are expected to lead to greenhouse gas emission reductions are micro-economic reform of the Energy Sector and the Greenhouse Challenge Program.

In greenhouse terms, micro-economic reform can have positive impacts through facilitating fuel switching and greater use of renewable energy and encouraging greater efficiency in generation, as well as negative impacts due to reductions in the price of energy, which induce greater use.

The Greenhouse Challenge has led to a growing number of voluntary agreements by major greenhouse gas emitters to reduce their emissions relative to 'business-as-usual' scenarios. Other significant developments include the introduction of minimum energy performance standards for appliances, the creation of the Sustainable Energy Development Authority and introduction of the *Electricity Act* in the State of New South Wales, and the establishment of the Cooperative Research Centre on Renewable Energy. The projection shown in Figure 5.1 takes account of all current measures.

Many of these measures are estimated to have low impacts on emissions due to assumed low penetration rates and an assumption that funding would not continue beyond the current life of programs. With stronger implementation, the impacts would be larger.

The estimated impacts of most measures have been reduced by 10% to account for the 'rebound effect'. This recognises that savings in energy can reduce costs and increase competitiveness, thereby increasing output and energy use – offsetting to some degree the initial savings. The rebound effect has not been explicitly included in Australian or other countries' projections in the past, and industry and some States have questioned its validity and size. Further analysis of this effect will be required. As incorporated in this assessment, it does not substantially alter the results.

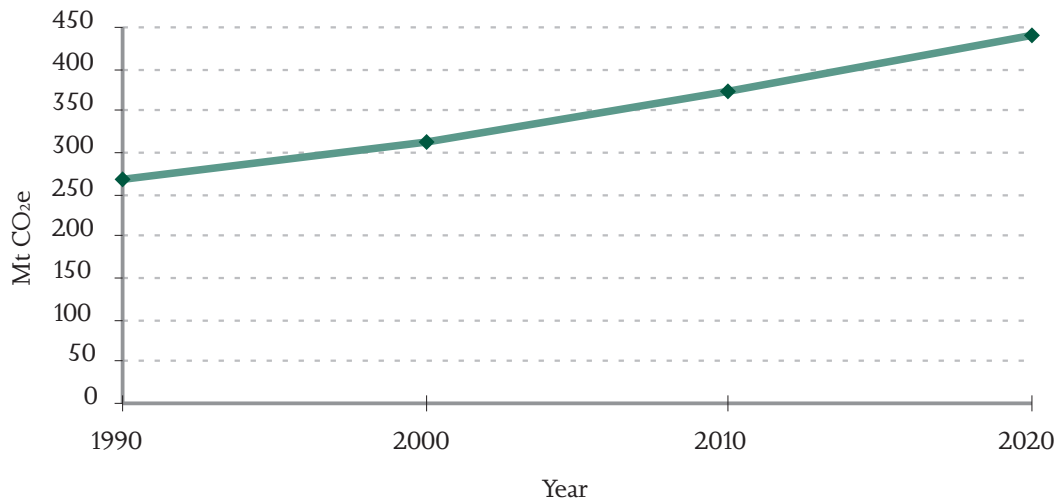


Figure 5.1 does not include the impact of outcomes of negotiations currently under way to improve the fuel consumption of Australian passenger cars and light commercial vehicles. These could lead to significant reductions in emissions.

Projections of Energy Sector emissions

The best estimate of Energy Sector emissions growth is a 40% (106 Mt) increase from the 1990 level of 267 Mt to 374 Mt CO₂-e in 2010. This takes account of the estimated impacts of policies currently in place that will reduce greenhouse gas emissions from the levels they would otherwise reach.

Figure 5.1 Emissions from the Energy Sector



In the absence of current policies, the best estimate for this sector is that emissions would grow by 48% (to 396 Mt CO₂-e). Thus, current measures are expected to reduce emissions to a figure 22 Mt CO₂-e below that which it would otherwise have been.

Fugitive Fuel emissions

Scope of sector

This sector covers primarily CH₄ emissions from coal mining and CO₂ vented and flared from gas and oil production. Fugitive emissions were responsible for 5% (26 Mt CO₂-e) of Australia's greenhouse gas emissions in 1990.

Analytic approach followed

The ABARE FES (Fuel and Electricity Survey) is based on, among other things, company estimates to 2010 of the growth of coal and petroleum production. These growth estimates, applied to National Greenhouse Gas Inventory estimates, published in 1994, of fugitive emissions from the Energy and Transport Sectors, were used to produce the baseline estimates.

Baseline projections

Fugitive emissions were expected to reach 42 Mt CO₂-e in 2010 in the absence of measures, an increase of 66% over 1990 emissions.

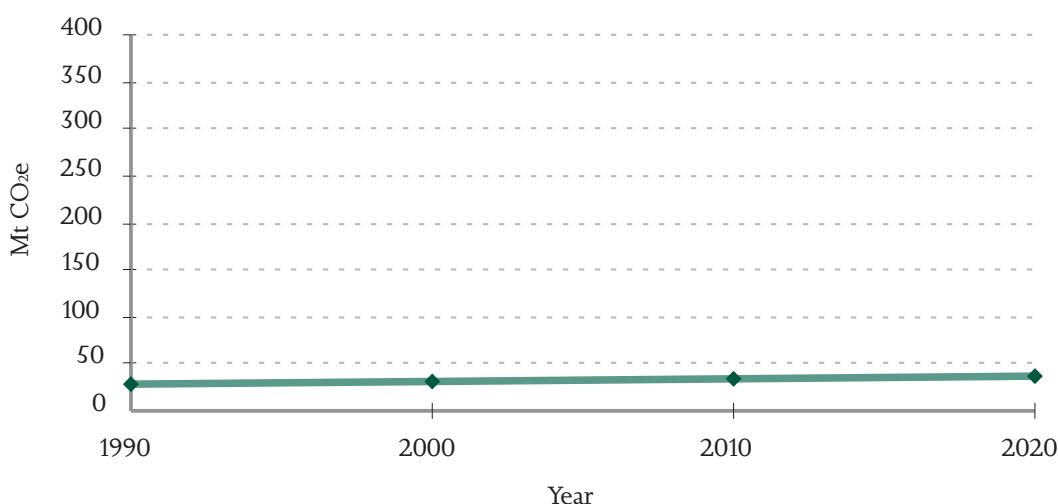
Effects of policies already in place

The ABARE FES provides a with-measures projection of fugitive emissions. About half the reduction in fugitive emissions from the baseline estimate is the result of specific measures already identified through the Greenhouse Challenge Program. The remainder is attributed to further CH₄ capture projects yet to be notified to that program.

Projections of fugitive emissions

The best estimate of fugitive emissions growth is a 12% (3 Mt CO₂-e) increase from 1990 levels to 29 Mt CO₂-e by 2010, as illustrated in Figure 5.2. This estimate is based on extrapolations of current trends and surveys of the energy industry. Current measures to address fugitive emissions are achieving significant reductions relative to what would be expected based on increases in output from the relevant sectors.

Figure 5.2 Emissions from the Fugitive Fuels Sector



Agriculture

Scope of sector

This sector covers emissions arising from the production of crops and livestock, but excludes those associated with vegetation removal or vegetation establishment on farms. Agriculture contributed about 17% (89 Mt CO₂-e) of total net emissions in 1990 (when land clearing emissions are excluded).

The main greenhouse gases emitted by the Agriculture Sector are CH₄ (56% of total national CH₄ emissions) and N₂O (80% of total national N₂O emissions). CH₄ is produced in the fermentation process in the digestive tracts of livestock, from manure under certain management conditions and from rice cultivation. N₂O is emitted from the soil as a result of soil disturbance in cropping and the application of fertiliser and animal excreta. Both these gases are generated in the burning of agricultural wastes and savanna.

Analytic approach followed

Future emissions from agriculture will be influenced by the level of production activities (cropping and livestock production) in response to domestic and international commodity demand. An Econometric Model of Australian Broadacre Agriculture (EMABA) developed by the Australian Bureau

of Agricultural and Resource Economics (ABARE) captures the variables involved and was used to predict activity data for the projection period. The effects of current measures were then estimated.

Baseline projections

Without any reduction measures, emissions from agriculture were projected to grow by 10% to 98 Mt CO₂-e in 2010.

Effects of policies already in place

Current measures comprise:

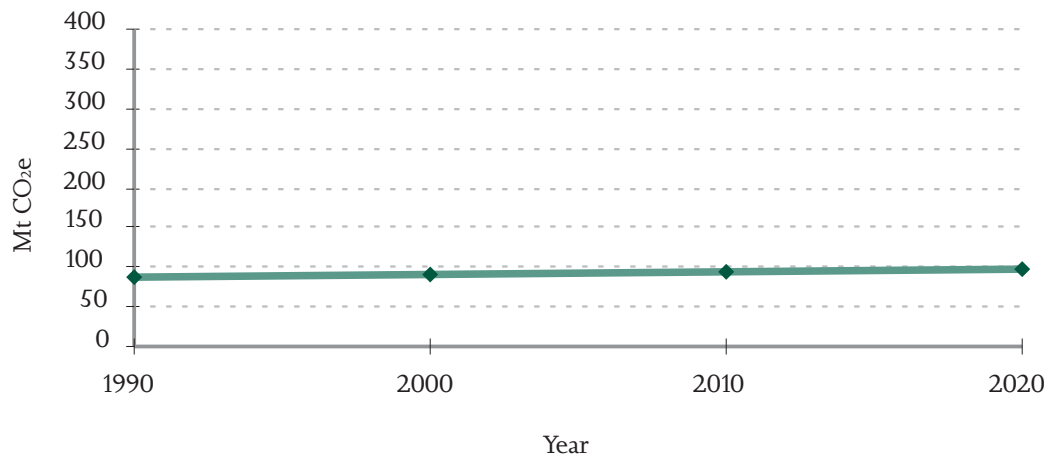
- research and education activities to reduce burning of agricultural residue;
- development of nitrification inhibitors to improve the efficiency of fertiliser uptake by crops;
- research and education activities to improve fertiliser application decisions;
- research and education activities to encourage minimum tillage and stubble retention practices;
- rehabilitation of rangelands through Landcare and extension; and
- promotion of the uptake of waste management technologies.

These measures are likely to produce relatively small reductions in emissions, and emissions are projected to continue to rise with this level of response. The implementation of grazing practices that result in land rehabilitation shows the greatest potential for reducing emissions, and also offers the non-greenhouse benefit of improved economic and ecological sustainability.

Projections of Agriculture Sector emissions

Projections show growth of 7% (6 Mt CO₂-e) from 1990 levels by 2010 with current measures (Figure 5.3).

Figure 5.3 Emissions from the Agriculture Sector



Forestry

Scope of sector

The Forestry Sector covers native forests managed for wood production, plantations, and national revegetation programs such as those under Bushcare: the National Vegetation Initiative. The main greenhouse gas emitted is CO₂.

Analytic approach followed

The Bureau of Resource Sciences estimated the changes in areas of plantation, managed native forests and revegetation over the projection period. Major factors influencing projections are increases in plantation area and in the quantity of timber harvested, including fuelwood. The area of managed native forests is assumed to remain constant. Using the Inventory methodology, the amount of CO₂ that would be absorbed in the growth of these types of vegetation was then calculated, as well as the CO₂ that would be released by the harvesting of timber from forests. A relationship exists between population growth and removal of timber from forests, so high and low scenarios were calculated using different estimates of population.

Uncertainty in the Forestry Sector has, in general, been addressed by adopting a conservative approach in determining emission projections. There is reasonable confidence in figures for the area of commercial plantations and the growth rates of trees, so appropriate available data were used. Less confidence exists in relation to both area and growth rates for managed native forests, so conservative estimates were used. For revegetation activities the uncertainty is higher still, and low estimates of area and growth rates were employed. As a result, Australia's forests (including revegetation) are likely to turn out to be a greater sink than has been estimated and presented here.

Baseline projections

Absorption of greenhouse gases by the Forestry Subsector, independent of any measures to increase sequestration or reduce emissions, was projected to increase in magnitude by 15% to -27 Mt in 2010.

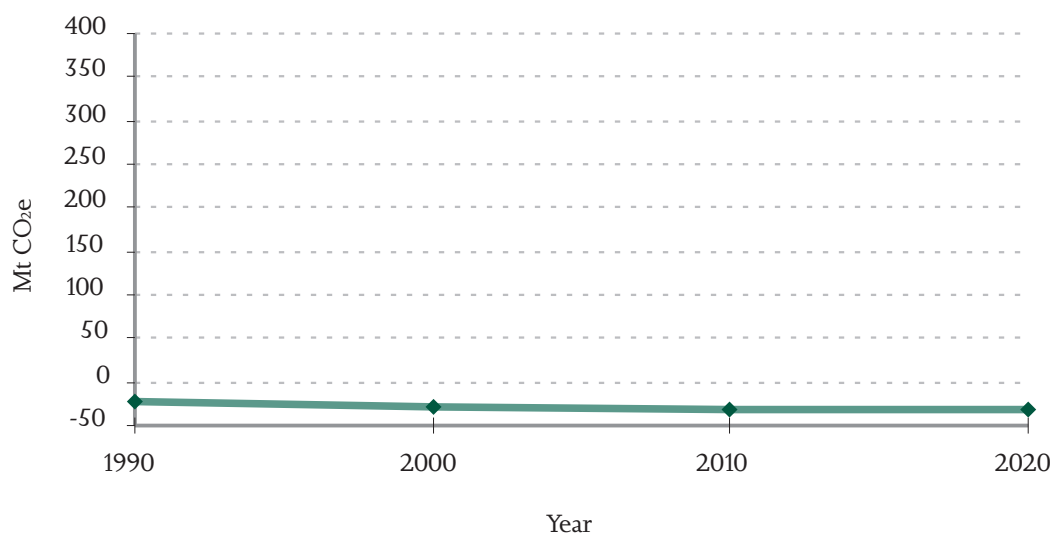
Effects of policies already in place

The largest proportion of the forestry sink in any year is provided by commercially managed native forests and plantations (84%, or 27 Mt in 2010). The National Vegetation Initiative contributes the remaining 16% (5 Mt) of the 32 Mt sink in 2010.

Projections of Forestry Sector emissions

Forestry is a net sink (that is, forests and growing vegetation overall absorb CO₂ from the atmosphere) and in 1990 this sector contributed about 5% (23 Mt) to net emissions. This sink capacity is projected to increase to 32 Mt in 2010 with current measures (Figure 5.4).

Figure 5.4 Net emissions from the Forestry Sector



(Sinks, or the absorption of CO₂, are depicted as negative emissions.)



Industrial Processes

Scope of sector

The Industrial Processes Sector covers cement clinker, aluminium and lime production, but does not include the energy component of these processes, which is accounted for under the Energy Sector. In 1990 the Industrial Processes Sector contributed 2% (12 Mt CO₂-e) of Australia's total greenhouse gas emissions. The main gases emitted are CO₂ and perfluorocarbons. CO₂ is emitted during the production of portland clinker, an intermediary product from which cement is made, and from the processing of raw materials in the production of lime and aluminium. Perfluorocarbons are emitted during the production of aluminium.

The analytic approach followed

Activity levels were projected from past trends and confirmed by consultation with peak industry bodies. This approach captured changes that are already taking place in the sector, and used conservative assumptions. The major factors influencing projections are economic activity and industrial growth, as well as the industrial processes considered. The main uncertainties relate to growth rates such as in the amount of lime used in crude steel production and to the timing of the introduction of supplementary cementitious materials into cement production in a major way.

Baseline projections

In the absence of measures, industrial emissions were projected to grow by 69% to 20 Mt CO₂-e in 2010.

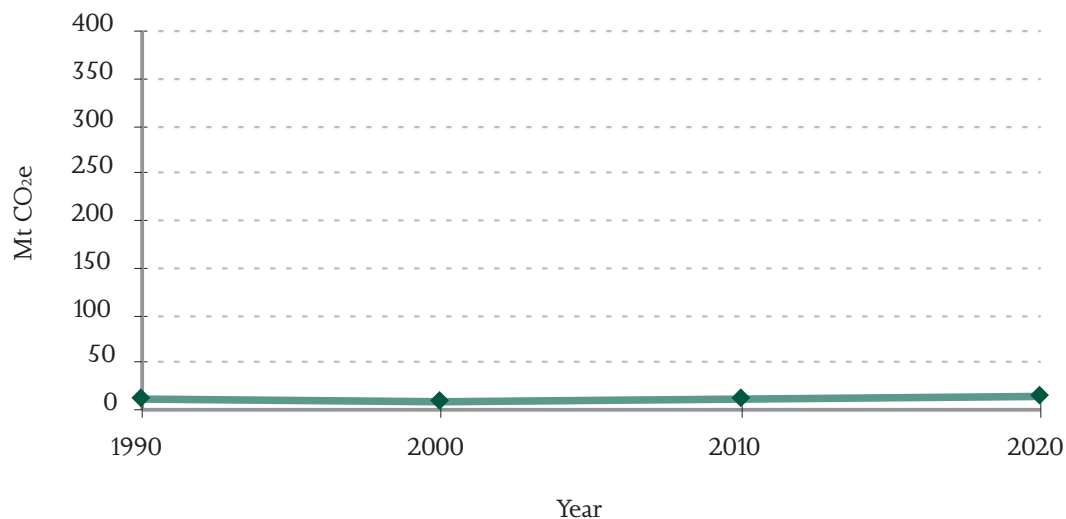
Policies already in place

These include cooperative agreements under the Greenhouse Challenge Program to reduce perfluorocarbon emissions from aluminium production, and increased use of supplementary cementitious materials in cement production.

Projections of Industrial Processes emissions

Emissions from this sector, which were just over 12 Mt CO₂-e in 1990, are projected to decline slightly to 2005 then rise again to the same level in absolute terms in 2010 (Figure 5.5). Although emissions of perfluorocarbons are expected to decrease over this period as the efficiency of aluminium production improves, the projected increase in CO₂ emissions from lime and cement clinker production with increased economic activity will offset this trend.

Figure 5.5 Emissions from the Industrial Processes Sector



Waste

Scope of sector

The Waste Sector covers municipal solid waste (landfill) and domestic, commercial and industrial wastewater. More than 90% of emissions from this sector come from solid waste. In 1990 the sector contributed 3% (15 Mt CO₂-e) of Australia's total greenhouse gas emissions. The main gas emitted is CH₄, generated from the decay of organic matter in the absence of oxygen.

Analytic approach followed

The major influences on activity levels in this sector are population growth, growth in waste per capita and increased economic and industrial activity. Conservative estimates were used, and the approach reflects changes that are already taking place in the sector. The main uncertainties relate to growth rates of population and GDP per capita, and changes in the amount of waste produced per capita.

Baseline projections

Waste emissions are projected to rise by 46% to 22 Mt CO₂-e in 2010 in the absence of measures.

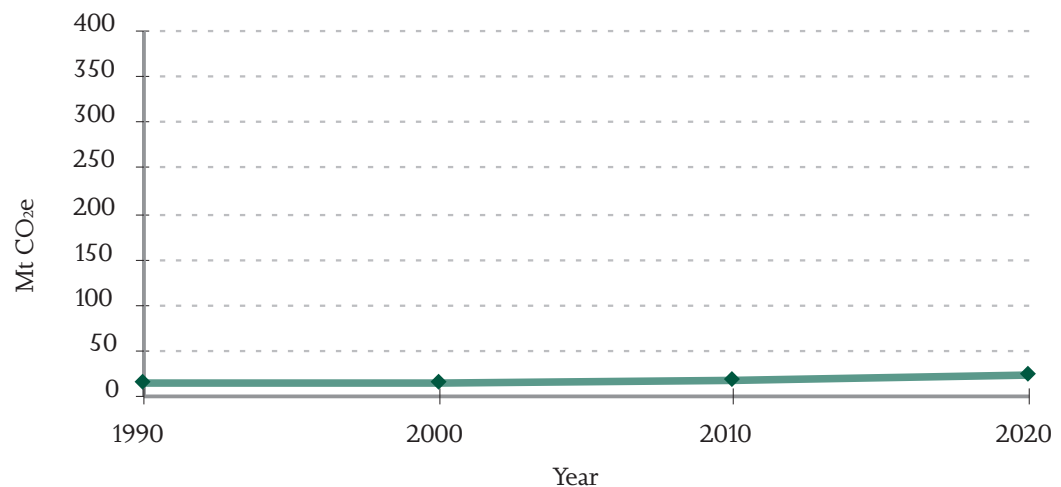
Key current measures

The main measure to reduce emissions is a reduction by 20% in the quantity of organic waste disposed to landfill. It is conservatively assumed that there is effectively no CH₄ recovered from landfill sites for energy production. There are no current measures to reduce emissions from wastewater.

Projections of Waste Sector emissions

Emissions from this sector are projected to continue to grow under current measures from 15 Mt CO₂-e in 1990 to 17 Mt CO₂-e in 2010, a 16% increase (Figure 5.6).

Figure 5.6 Emissions from the Waste Sector



Land Use Change

Scope of sector

This sector covers land clearing for sheep and cattle pasture and cropping. Inventory data show its share of total net emissions dropping from 20% to 13% between 1990 and 1995, reflecting a substantial decline in estimated emissions resulting largely from past clearing. Emissions are almost entirely in the form of CO₂. The release of CO₂ occurs in two zones: above ground when cleared vegetation is burnt or decays; and below ground when roots decay and soil carbon is released due to the disturbance. The below ground processes accounted for more than half of the 1990 emissions from land clearing, and a declining portion of subsequent emissions.

Analytic approach followed

This involved application of an ABARE econometric model (EMABA) to estimate future Australian livestock numbers and cropping area. As cattle and crops are primarily export commodities, the analysis is strongly influenced by changes in overseas markets. Another model is being developed to enable estimation of the amount of land that would be cleared as a result of the demand for crops and livestock projected by EMABA. Projections of emissions due to land use change are also influenced by biological processes regulating CO₂ emissions after clearing, and a critical feature affecting the modelling is the high level of uncertainty that exists about key processes.

Work in progress to improve the capability to calculate above ground carbon release is beginning to provide useful inputs to inventory compilation and the development of projections. Already, preliminary application of satellite imagery analyses has improved the uncertainty factor for data on annual clearing rates from around 50% to 30%. A substantial investment is being made in continuing efforts to improve estimates of emissions from land clearing activity.

Effects of measures already in place

At this stage, it is not feasible to provide projections of emissions from land clearing or effects of measures with the necessary minimum confidence level. Emissions projections from this sub-sector will be progressed as methodology and data are improved.

PROJECTED EMISSIONS GAS BY GAS

The tables in this section summarise the results of Australia's projections by greenhouse gas. It should be noted that the projections were made by sector, and gas by gas results are not available for all sectors. Where they are available, they have been included in the appropriate tables. Otherwise, the CO₂ equivalents for all emissions in the sector have been included in Table 5.2.

Sulphur dioxide, CO, NO_x, NMVOC and bunker fuel emissions were not estimated in Australia's projections.

Table 5.2 Summary of projections of anthropogenic emissions of CO₂ equivalents of all gases (gigagrams)

	1990	1995	2000	2005	2010	2020
Stationary Energy	205500	223000	242300	259200	280800	325000
Fuel combustion: transport	61800	68800	74500	83300	92600	113900
Fugitive fuel emissions	26000	25600	27700	28400	29200	30700
Industrial	12100	9000	10000	10900	12100	15000
Agriculture	88800	87400	92100	96800	94900	98100
Waste	14800	16400	15200	15300	17200	22400

Carbon dioxide

Table 5.3(a) Summary of projections of anthropogenic emissions of CO₂ in the Energy Sector (gigagrams)

	1990	1995	2000	2005	2010	2020
Stationary Energy	203000	220300	239400	256200	277500	321200
Fuel combustion: transport	59600	65200	71800	80300	89300	109900

Table 5.3(b) Summary of projections of removals of CO₂ by sinks and reservoirs (gigagrams)

	1990	1995	2000	2005	2010	2020
Agriculture			-2079	-2310	-2310	-2310
Forestry	-23100	-21100	-29000	-29300	-31500	-32800

Methane

Table 5.4 Summary of projection of anthropogenic emissions of CH₄ (gigagrams)

	1990	1995	2000	2005	2010	2020
Fuel Combustion	80	90	95	100	110	125
Transport	30	35	35	40	45	55
Fugitive emissions from fuel			See Table 5.2			
Industrial Processes			See Table 5.2			
All Agriculture	3200	3150	3350	3500	3400	3450
Waste			See Table 5.2			

Nitrous oxide

Table 5.5 Summary of projections of anthropogenic emission of N₂O (gigagrams)

	1990	1995	2000	2005	2010	2020
Transport	5	6	6	7	8	10
Fugitive fuel emissions			see Table 5.2			
Industrial Processes			see Table 5.2			
Agriculture	68	69	78	82	83	89
Waste			see Table 5.2			
Forestry	0	0	0	0	0	0

PFCs, HFCs and SF₆

Australia's emissions of PFCs were estimated as CO₂ equivalent emissions and incorporated in the Industrial Processes Sector on that basis. Australia had no emissions of HFCs in 1990, and projections of emissions of HFCs and SF₆ were not made.

CO, NO_x and NMVOCs

These gases were not included in projections of Australia's emissions.



Sulphur oxides

Information on emissions of sulphur oxides has been collected for 1995 only, and no projections were made for these gases.

Bunker fuel emissions

Projections of bunker fuel emissions were not made.

DIFFERENCES BETWEEN THE FIRST AND SECOND NATIONAL COMMUNICATIONS

Estimates of emissions for the base year 1990 have changed since Australia's first National Communication under the Framework Convention on Climate Change (September 1994). Inventory data are subject to periodic revision as a result of changes in the international guidelines, new information about the Australian situation, and better scientific understanding of relevant processes. For example, the change in Global Warming Potential values for CH₄ and N₂O since Australia's first National Communication is especially significant for Australia because of our relatively high CH₄ emission levels.

These and other factors result in Australia's emissions base for 1990 now being around 15% lower than when it was incorporated into our first National Communication. It should be noted that the factors that affect the emissions base for 1990 also affect projections in a similar way.

References

- Aquatech Pty Ltd Environmental and Economic Consultants, 1997, *Projections to 2020: Greenhouse Gas Emissions from Industrial Processes*, Report to the Department of the Environment, Sport and Territories, unpublished.
- Aquatech Pty Ltd Environmental and Economic Consultants and CMPS&F, 1997, *Projections to 2020: Greenhouse Gas Emissions from Waste*, Report to the Department of the Environment, Sport and Territories, unpublished.
- Commonwealth Energy Projections Working Group, 1997, *Projected Greenhouse Gas Emission from the Energy Sector: 1990-2020*, June 1997, unpublished.
- Lucas, Richard M, 1997, *Projections of Greenhouse Gas Sources and Sinks from the Australian Forestry Sector to the Year 2020*, Report to the Department of the Environment, Sport and Territories, unpublished.
- Noble, Ian, 1997, *Projections of Land-use Change and Associated CO₂ Emissions*, Report to the Department of the Environment, Sport and Territories, unpublished.
- Reyenga, P J, Howden, S M, 1997, *Projections of Greenhouse Gas Emissions from the Australian Agriculture Sector to the Year 2020*, Report to Department of the Environment, Sport and Territories, unpublished.

Impacts, vulnerability and adaptation

CONTEXT

A variety of features of Australia complicate assessment of the impacts of global warming. With a land area of more than 7.6 million square kilometres extending from the tropics well into the middle latitudes, the country encompasses a wide range of climatic regimes. Apart from Antarctica, Australia is the world's driest continent, with a vast arid and semi-arid interior. It is also the only island continent, with the surrounding oceans playing a major role in determining its climate.

Australia experiences large variations in rainfall. Droughts and floods are common occurrences. Records for this century show that, averaged over the continent, more than twice as much rain fell in the wettest year as in the driest, and year-to-year variability within regions is much greater still. Impact assessment has to consider this naturally occurring large climate variability, part of which is due to Australia's location in a region strongly influenced by the El Niño–Southern Oscillation (ENSO). Australian research is currently analysing whether, and how, global warming might affect the ENSO phenomenon.

Other important considerations in impact assessment include Australia's status as one of the world's regions of biological megadiversity and the fact that its soils are particularly fragile – low in nutrients, easily eroded, and susceptible to salinisation over large areas.

As a country highly dependent on international trade to service its people and economy, Australia may 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 suggest 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 substantial 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 will be incomplete without the inclusion of a global perspective on these issues.

Studies of many potential impacts of the enhanced greenhouse effect have been conducted in Australia over the past decade, and the research effort is continuing. Most projects use scenarios indicating the likely range of regional changes in temperatures and rainfall as their starting point. The studies are defining the extent of potential impacts on natural environments, communities, industries, infrastructure and the economy. They will help guide the development of adaptation strategies aimed at minimising adverse effects and taking advantage of new opportunities presented by climate change.

CLIMATE CHANGE

Scenarios for assessing impacts

Over the past ten years CSIRO has produced a series of scenarios for the effects of global warming utilising global climate model (GCM) simulations in the Australian region. These are not forecasts, as future regional climates cannot yet be predicted with any precision; rather they describe a range of

possible climate change outcomes. They have provided the starting point for most climate change impact studies undertaken in Australia to date.

CSIRO's latest set of scenarios, issued in November 1996, takes as a starting point the global greenhouse gas emissions scenarios in the IPCC's Second Assessment Report. The scenarios make use of advances in methodology such as the development of fully coupled ocean-atmosphere models, directly linking global atmospheric and ocean models. Notable features of the new scenarios are a significant narrowing in the ranges of projected temperature increases – due mainly to reductions at the high end largely reflecting changes in the IPCC's global warming estimates – and lower estimates of summer rainfall from the coupled models.

The new scenarios provide figures for magnitudes of changes in temperature and precipitation per degree of global warming, together with projections for the years 2030 and 2070 derived from the IPCC's low and high case global warming scenarios.

Temperatures

To highlight differing regional patterns of response to global warming in Australia, three regions – northern coastal, southern coastal and inland – were delineated for the temperature changes. Table 6.1 shows the scenarios for temperature. Australia's largest population centres – Sydney, Melbourne, Brisbane, Perth and Adelaide – are all in the southern coastal region, for which possible temperature rises of 0.8–1.6°C per degree of global warming are indicated. Larger rises are expected in the inland and smaller ones in the northern coastal region.

Table 6.1 Scenarios of temperature change (°C) for locations in the Australian region

Region	Local warming per degree of global warming	Warming in 2030	Warming in 2070
Northern Coast (north of 25°S)	0.9 to 1.3	0.3 to 1.0	0.6 to 2.7
Southern Coast (south of 25°S)	0.8 to 1.6	0.3 to 1.3	0.6 to 3.4
Inland	1.0 to 1.8	0.4 to 1.4	0.7 to 3.8

Models suggest that increases in minimum and maximum temperatures are likely to be similar, except where there are also changes in rainfall and cloudiness. Wetter, cloudier conditions will lead to greater increases in minimum temperatures, and drier, clearer conditions to greater increases in maximums. No clear patterns of change in daily temperature variability were discerned, but a significant increase in average temperature could bring a marked decrease in the frequency of extremely cold weather and a similar increase in the frequency of extremely hot days.

Precipitation

Scenarios for changes in rain and snowfall were derived from the coupled model experiments used for temperature estimation and from simulations employing 'slab ocean' GCMs, which use a much simpler representation of the ocean than coupled models. Both types of model simulated decreases in winter rainfall over most of mainland Australia and increases generally over Tasmania. For summer rainfall, the coupled models suggested little change in the east and south-west of the continent, regions encompassing the major population centres. Reductions were indicated over the rest of the country – Tasmania, the Northern Territory, most of Western Australia and South Australia, and much of Queensland. Slab ocean models, on the other hand, projected general increases in summer rainfall (see Tables 6.2 and 6.3).

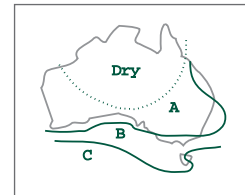
The rainfall projections from both types of model indicate that regions that have insignificant amounts of rain in winter will remain dry. Changes in spring and autumn rainfall should, in general, be transitional between the summer and winter patterns. The rainfall change figures shown in Tables 6.2 and 6.3 apply to broad areas; significantly larger or smaller changes can be expected locally, particularly where topography strongly controls rainfall patterns.

The current state of the science prevents explicit allowance being made in the scenarios for three factors that may also affect future rainfall over Australia - possible changes in regional ocean circulation, in large-scale atmospheric circulation due to increasing levels of sulfate aerosols in Asia, and in the behaviour of ENSO.

Table 6.2 Scenarios of precipitation change for locations in the Australian region based on coupled models

Winter

Location	Response per degree of global warming	Change in 2030	Change in 2070
Region A	-10 to 0%	-8 to 0%	-20 to 0%
Region B	-5 to +5%	-4 to +4%	-10 to +10%
Region C	0 to +10%	0 to +8%	0 to +20%



Summer

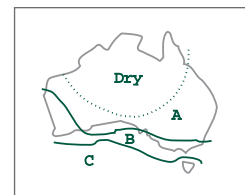
Location	Response per degree of global warming	Change in 2030	Change in 2070
Region A	-10 to 0%	-8 to 0%	-20 to 0%
Region B	-5 to +5%	-4 to +4%	-10 to +10%



Table 6.3 Scenarios of precipitation change for locations in the Australian region based on slab models

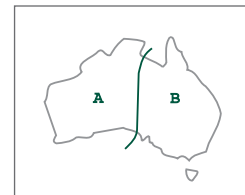
Winter

Location	Response per degree of global warming	Change in 2030	Change in 2070
Region A	-5 to 0%	-4 to 0%	-10 to 0%
Region B	-2.5 to +2.5%	-2 to +2%	-5 to +5%
Region C	0 to +5%	0 to +4%	0 to +10%



Summer

Location	Response per degree of global warming	Change in 2030	Change in 2070
Region A	+5 to +15%	+2 to +12%	+4 to +30%
Region B	0 to +10%	0 to +8%	0 to +20%



Rainfall intensity

CSIRO studies found that, where models simulated rises in average rainfall, these were associated with increases in rainfall intensity. The tendency towards intensity increases was less marked or absent where the simulations pointed to reduced rainfall.

The findings of a study of rainfall in northern Australia support projections of increases in the intensity and frequency of heavy falls with global warming. Examination of rainfall records from 1910 to 1989 found increasing trends in intensity, based on falls on the top 10% of rainy days, at 46 of 53 measuring stations. Most of these stations also showed increases in the frequency of heavy rainfall. While ENSO strongly influences rainfall in northern Australia, the study demonstrated that this was not the sole cause of the increases. Preliminary findings from an extension of the study to the rest of Australia suggest that most regions have experienced increases in heavy falls.

Sea-level rise

Rises in sea level that might be caused by possible thermal expansion of the ocean's upper layers and ice-melt due to global warming are an additional major consideration in impact assessment. These are likely to have significant social, economic and ecological consequences in coastal regions. To provide precise data on movements in sea level, the National Tidal Facility at Flinders University, Adelaide, has established a network of 16 monitoring stations around Australia.

Sea level in the Australian region is currently estimated to be rising at an average rate of between 1 and 2 millimetres a year. Future rates of change are highly uncertain, with the IPCC projecting a mean global rise of between 15 and 95 centimetres by the year 2100. Rates of rise will vary substantially between locations because of different rates of ocean warming and expansion, effects of regional changes in oceanic and atmospheric circulation, and geological factors. Inhabited islands in the Torres Strait are particularly vulnerable to sea level rise and other climate change related impacts.

CO₂ fertilisation

Major impacts can also be expected from the direct effects of rising concentrations of CO₂ in the atmosphere. The CO₂ concentration is now about 30% higher than at the start of the Industrial Revolution 200 years ago, and is expected to be nearly double the pre-industrial concentration by 2100. Increases in CO₂ levels alter rates of plant growth and the composition of plant tissue through 'CO₂ fertilisation'. Potential effects on natural ecosystems, crops, pastures and forestry need to be considered in impact studies.

ENVIRONMENTAL IMPACTS

Impacts of climate change on the natural environment could be significant both in themselves and for their possible flow-on effects to agriculture, infrastructure requirements and human activities generally. This section deals with major environmental effects, some of which will have important social and economic consequences. The next section, 'Socio-economic impacts', focuses on some of the most significant possible impacts of climate change on Australia's economy and society.

Hydrology

Runoff and flooding

Scenarios indicate that changes in rainfall quantity and intensity across Australia could have major impacts, which research is beginning to quantify. One study estimated that changes in runoff will be much larger than those in the amount of rain falling – perhaps twice as great in wet and temperate areas and five times larger in arid areas. In drier areas, percentage changes in soil moisture may also be greater than the change in rainfall. Another study found that increased flooding may occur in many areas because of increases in peak runoff.

Two climate change scenarios were considered in a project that modelled impacts on streamflow in two river basins in Victoria. The 'pessimistic case', representing the expected lower limit for river discharge, suggested that streamflow would be about one-third lower in 2030 than now and two-thirds lower in 2070. In this case, the probability of floods would decrease rapidly. On the other hand, the 'optimistic' upper limit case projected little change in average streamflow but a doubling of flood frequency by 2070. The findings indicate that climate change may have substantial implications for water supply, agriculture and possibly flood control in this region, although these cannot be defined accurately yet.

A study of the possible impacts of climate change on the scarce water resources of the Macquarie River Basin in northern New South Wales showed mean annual runoff to the major dam on the river falling by 9% by 2030 under a low change scenario and by 29% in the high change case. With less water available, a decline of 12–35% in the region's economy was predicted. Due to the reduced water flow into the Macquarie wetlands, and particularly to reduced flooding, some bird species might breed less frequently, possibly resulting in local or regional extinctions.

Erosion, salinity and siltation

A study of the implications of climate change for land degradation in New South Wales found large increases could occur in the areas affected by sheet and rill erosion and dryland salinity. This latter problem, caused by increased groundwater recharge following the clearing of native vegetation, has become a major concern in many agricultural regions in southern Australia, with the total area affected estimated at more than one million hectares. Increases in rainfall intensity may result in greater inputs of organic material and sediments to waterways, reducing water quality and adding to the nutrient poverty of Australia's soils.

Snow cover

Global warming is expected to cause a substantial reduction in the duration of winter snow cover in Australia. Modelling studies indicate that this is very sensitive to changes in temperature and less sensitive to changes in precipitation. Significant cover is 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 1200–1400 metres and for periods of up to several months higher in the mountains. Research is in progress to determine how the expected reduction in snow cover will affect sensitive alpine plant and animal communities. Possible effects on the tourism industry in alpine regions are also being studied (see 'Tourism'), as are the potential impacts of a reduced spring snow-melt on hydro-electricity production and downstream irrigation industries.

Fire danger

A study using CSIRO's 1992 scenarios has shown that the climate change resulting from a doubling of CO₂ levels in the atmosphere may produce more days of high and extreme fire danger over much of Australia, largely due to decreases in relative humidity.

Forest and grass fires are frequent occurrences in the Australian summer, sometimes causing loss of life and major property damage; for example, insured losses from bushfires in New South Wales in January 1994 exceeded \$150 million. An increased fire risk due to global warming may increase such costs.

Fire plays an important role in many Australian ecosystems; 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. In addition, an increased fire risk may present dangers to plant communities such as rainforest that are not adapted to fire. Australia also experiences major ENSO-related bushfires causing loss of property and life. Any changes to ENSO caused by global warming have the potential to be reflected in fire regimes in ENSO-affected areas of Australia.



Plants

Distribution

Climate change is also anticipated to have direct impacts on Australian flora. Species that can thrive in a range of environments or have a strong capacity for dispersal and establishment are likely to cope better than those with narrow requirements or that are slow to migrate. Modelling suggests, for example, that global warming by just 1°C could place Mitchell grass, a key species across large areas of northern Australian pasture land, at risk. Mitchell grass has a narrow soil type preference, and the study projects a significant reduction in the area combining suitable climate and soils.

Implications of shifting climatic zones for plant conservation are under study. Research in southern Western Australia, for instance, has projected drastic reductions in the distribution of four species of *Dryandra*, a group of native shrubs. The analysis suggests that global warming may see the areas suited to these species contract and move away, either largely or completely, from the regions where they are found now. Findings such as this highlight the risk that endangered species restricted to reserves established to protect them in today's climate may die out as conditions in the reserves change. This points to an increasingly important role for off-reserve management.

Weeds

As weed species are highly adaptable and can rapidly exploit environmental stress, climate change may cause increased weed problems in many ecosystems. The importance of individual species is also likely to change, with the different ways plants produce carbohydrate by photosynthesis possibly having an influence. Australia's tropical grasslands are generally dominated by species that use the C4 photosynthetic process. C4 plants may not show as great a response to increased CO₂ availability as C3 plants. Various C3 weeds may thus acquire a competitive advantage in this environment.

The modelled shift towards a greater frequency of high rainfall events and longer dry periods will favour increased establishment of drought-tolerant woody weed species at the expense of grasses in Australia's semi-arid grasslands. These weeds, which can convert open grassland to savannah thicket, are already a major problem for the grazing industry.

Plant productivity and growth

Research has shown that increased concentrations of CO₂ in the atmosphere generally boost plant growth, particularly under water-limited conditions. In addition, nitrogen-fixing plants tend to fix more nitrogen in their roots when CO₂ levels are higher and other factors do not limit growth; as a result, soil nitrogen may gradually build up, also favouring an increase in plant growth. On the other hand, higher CO₂ levels cause a reduction in the ratio of nitrogen to carbon in plant tissues. This may result in reduced rates of litter breakdown and nitrogen mineralisation in the soil, with long-term adverse consequences for productivity. Slower litter breakdown may also increase fire risk. Studies are attempting to quantify the effects of CO₂ fertilisation in various ecosystems as well as assess the likely impacts of changes in temperature and rainfall regimes.

Work to date suggests that grasslands in regions of summer rainfall should show increased growth, but the forage may be of lower quality for grazing animals because of lower nitrogen levels. A study of the impact of rises in temperature and CO₂ on forests found that a doubling of atmospheric CO₂ could produce a strong initial increase in productivity under nutrient-limited conditions, with the increase continuing over the long term but at slower rates.

Pests

Climate change may also affect insect pests of both natural ecosystems and crops and pastures. Temperature increases will allow southward extension of the range of some species; examples include

the cattle tick and Queensland fruit fly. In some cases, warmer conditions will also increase the numbers of insect generations in a year, leading to higher pest populations. Outbreaks of plague locusts are triggered by heavy rainfall in the normally arid inland, and may become more severe with the predicted increase in the intensity of major rainfall events.

Native animals

Distribution

Findings from studies that have examined how global warming may alter the areas with climates suited to particular native animals suggest that many species will be placed under considerable pressure. A bioclimatic analysis and prediction modelling tool known as BIOCLIM has been employed in these studies.

A project that looked at possible impacts on a small number of rare and common animals found that the species with a limited distribution or specific soil or habitat requirements were those most likely to be adversely affected. Some species, for example grey kangaroos, have wide geographic ranges and thus broad climate profiles, as well as tolerance for a variety of vegetation and soil types. Others have much narrower requirements. The kowari, a small mammal restricted to desert country in south-western Queensland and neighbouring South Australia and the Northern Territory, was found to be the most vulnerable species of those examined. Areas of suitable climate were projected to both contract significantly and move to regions where the vegetation and soils do not suit kowaris.

Threatened species

Another major project used BIOCLIM to predict the impact of climate change on the distribution of 57 animal species listed as threatened. Three climate change scenarios were chosen to represent the widest range of possible change, and in each case a contraction in core climatic habitat was projected for more than 80% of species. Those most affected tended to be the same regardless of scenario.

Under the mildest change scenario – a temperature rise, varying with region, of between 0.3 and 0.8°C and no change in rainfall – no species experiences complete elimination of its bioclimatic range. However, a reduction in range of more than 90% was projected for three species – the kowari and two other small mammals. Two more mammals, a bird, a fish and a snake may lose, according to the simulation, more than 65% of their bioclimatic habitat. Gains in bioclimatic range were found for 10 species; these varied from 2.9% (Leadbeater's possum) to 34.7% (the dibbler, another small mammal). A greater climatic range alone would not be useful to a species unless other critical environmental factors were met. The Leadbeater's possum, for example, also requires old-growth eucalypts.

Under the other two scenarios – a large temperature rise (1.0–1.4°C) and small increase in rainfall, and larger increases in both temperature and rainfall – the model indicated that the bioclimatic ranges of three mammals, three birds and a lizard may no longer exist, and perhaps, therefore, the species. Many other species could experience major reductions in their range, and only two or three might end up with an extended range. The findings confirm that global warming poses major challenges in biological conservation.

Antarctic ecosystems are also vulnerable to global warming. Any progressive loss of the Antarctic ice shelf could lead to a reduction in marine life in both the Australian Antarctic Territory and the associated exclusive economic zone adjacent to this Territory.

Coastal impacts

Possible impacts of global warming on coastal ecosystems will result from both rises in sea level and changes in the intensity and frequency of storms. The biggest problems are likely to arise in regions where climate change increases the risk of sea water being swept ashore in storm surges.



In northern Australia, an important question is whether changes can be expected in the frequency, intensity and paths of tropical cyclones, which can cause major wind, rain and storm surge damage. Recent research, using scenarios with a doubling of atmospheric CO₂, suggests that maximum intensities of tropical cyclones could increase by up to 10–20%. However, it indicates that the affected regions will probably not change significantly and that little or no change in global cyclone frequency is likely, although regional and local frequencies could change substantially.

Australia has played a leading role in the development of methods for assessing the vulnerability of coastal areas to climate change impacts. Australian researchers developed a revised approach after trials of methodology published by the IPCC in 1991 revealed a number of weaknesses. Nine case studies have since been conducted around Australia, focusing on the impacts of human activities as well as global warming.

One finding was that, in the Alligator Rivers Region of the Northern Territory, all wetland areas up to 4 metres above sea level are vulnerable to climate-induced changes including intrusion of salt water; these wetlands are recognised as having high conservation value. Lowland monsoonal rainforests, important remnant habitats on the coastal plain, are also vulnerable. The study at Bateman's Bay, New South Wales, found that estuarine mangrove forests and salt marshes are extremely vulnerable to changes in sea level. The Port Phillip, Victoria, study suggested the possibility of significant inundation impacts, and identified vulnerable areas. While the study at Perth, Western Australia, found that future sea level rises would not cause extensive retreat of the shoreline, the Gippsland Lakes, Victoria, study projected shoreline retreat of up to 20 centimetres a year in some areas. Although considerable beach erosion would occur, the likelihood of dunes being breached by seawater was considered small.

Coral reefs

The Great Barrier Reef, extending for about 2000 kilometres along Australia's north-eastern coast, is the world's largest complex of coral reefs and islands. Other notable reef complexes are found off the west coast. Studies have been conducted of the potential effects of global warming on these sensitive environments.

Higher sea levels are expected to benefit many reefs as they will allow increased coral growth on reef tops. Most shallow corals should be able to keep pace with a sea level rise of up to 5 centimetres per decade, which is at the high end of projected rates. Increases in sea temperature are expected to be slow enough to allow the coral biota to adapt. Coral bleaching has been associated with increased sea surface temperatures, and some scientists have suggested that increased bleaching and subsequent coral death may be another impact of climate change.

SOCIO-ECONOMIC IMPACTS

Agriculture

Impacts of climate change on agriculture are a key concern to Australia because of this sector's importance to the national economy. Most of the produce of Australia's farms and pasture lands is exported; in 1996/97 receipts from exported wool, meat, grain and sugar totalled more than \$14 billion, with other rural exports bringing in a further \$9 billion.

Assessing potential impacts is extremely difficult, not only because of the uncertainty about future regional temperature and rainfall regimes. Many other factors also have to be taken into account. These include the effects of CO₂ fertilisation on both plant productivity and the quality of crops and pastures, the impacts of climate change on weeds, pests and diseases, and the effects of global climate change on world prices for agricultural commodities. A wide range of relevant studies have been conducted and many more are in progress.

Growing regions

A study that focused on irrigated agriculture in eastern Australia's Murray Darling Basin found that horticultural cropping may need to shift gradually to the south, to cooler, higher country. The area of rice under irrigation may contract; alternatively, rice production could shift northward to areas with greater water availability. Cotton producers might benefit from an extended growing season, and regions under this crop could expand southward. Another study found that a temperature rise exceeding 1.5°C in southern Australia could significantly reduce the quality and yield of both stone and pome fruits over wide areas due to a lack of sufficient chilling to break winter dormancy.

Productivity

Considerable research has been conducted into impacts on grain production. However, the overall response of grain yields to climate change is hard to predict, and the availability of plant species suited to the changing conditions will have an important influence.

One project developed a process-based model of grain growth that can be used to study the effects of increased temperatures and CO₂ concentrations on grain yield. Among its findings are that a doubling of CO₂ alone could increase average yields from long-season genotypes by 10–30%. However, the same study found that a 3°C temperature increase alone could reduce yields by up to 50%.

Other work suggests that grain yields are likely to rise much more in response to increasing CO₂ levels in warm to hot areas than in cool regions. Increased CO₂ may also increase tolerance to water stress. However, where temperatures are already marginal for grain growing, further warming will produce lower yields despite any benefits from the additional CO₂.

Research on potential impacts on wheat grain quality has also shown that higher CO₂ levels tend to decrease protein content and that extended exposure to extreme heat has a detrimental effect on dough strength.

Studies of impacts on pasture production have been conducted in both temperate southern regions and the rangelands of northern Australia. Findings include a potential increase in net primary production in improved temperate-zone pasture in autumn and winter due to higher temperatures, with a slight decline possible in spring and little change in summer. In the native pastures of the north, forage production is projected to increase, at least in some years. On the other side of the ledger, CO₂ fertilisation will reduce the protein content of the forage. One possible outcome will be a need for stocking rates to be even more flexible than they have to be now in this climatically highly variable region to avoid overgrazing and subsequent land degradation.

Pests, diseases and weeds

Research has been undertaken on the effects of climate change on agriculturally important pests, diseases and weeds. Southward extensions to the ranges of pests now confined to warmer northern regions are probable. For example, the Queensland fruit fly, one of Australia's most damaging arthropod pests, may invade and cause severe damage in the fruit-growing areas of the south-east. The cattle tick, a major pest in north-eastern regions, may spread to the dairy production areas of southern Australia as well as becoming more active within its current range. An economic assessment estimated annual losses of farm income due to increased tick activity at \$1–6 million in 2030, with increased tick densities in southern Queensland the main cause.

Diseases of concern include anthracnose, which has the capacity to wipe out some pastures based on stylo legumes. Studies have shown that increased CO₂ levels in the atmosphere result in the anthracnose fungus producing more spores in less time. Weeds are likely to cause increased problems for crop growers and graziers, one of their characteristics being an ability to rapidly exploit changed environmental conditions.



Climate change and associated extremes in soil moisture may increase insect related defoliation and loss of mature trees from farmed land, increasing the costs of rural tree decline. This has economic impacts ranging from reduced livestock productivity to loss of visual amenity. A study of the New England region, NSW, estimated financial losses due to accelerated insect related tree decline for 2030. Depending on the climate change scenario used - ie. whether derived from the coupled or slab regional CSIRO climate models - estimates were between \$76 million and \$248 million in current dollar terms with a 6% discount rate.

Research is under way on the broad economic impacts of global warming on Australian agriculture, including effects due to changes in agricultural commodity markets. Early results suggest that possible benefits from greater dry matter production could be eliminated quickly by increased losses due to pests, diseases and weeds, particularly in northern Australia.

Forestry

Productivity

More than half of Australia's wood production comes from about one million hectares of softwood plantations and 130 000 hectares of planted hardwoods; the remainder is harvested from sections of the country's 40 million hectares of native forest. Potential impacts of climate change on the productivity of both plantations and natural forest are being investigated using tree growth models. Early results suggest that forest productivity responds strongly to increased CO₂ and temperatures initially, but that the response diminishes with time. Progress in the research includes incorporation of feedback between changes in litter chemistry and soil nitrogen dynamics into the models, and a range of experiments are being conducted to simulate the long-term effects of climate change in different environments.

Growing regions

Forest productivity would be affected by shifts in climatic zones accompanying global warming. Because decades of growth are needed to produce a marketable log (the actual rotation time varies with species, environment, management approach etc.), climate change could have a substantial impact during a single production cycle. Calculations suggest that, in terms of temperature, the locations where conditions are optimal for particular species are moving south at a rate averaging about 1.5-5.5 kilometres a year. Many of Australia's softwood plantations are in regions where temperatures are already at the upper edge of the suitable range, so impacts may be felt quite soon. Stresses caused by changes in temperature and rainfall regimes may result in increased damage to trees by pests and pathogens. Increases in fire risk are a potential additional hazard.

Human health

Climate change may have a range of impacts on the health of Australians, including some with potentially substantial social and economic consequences. Research to date indicates that indirect impacts, such as effects on the spread of mosquito-borne viral diseases, will be more significant than the direct impacts.

Heat stress

Predicted increases in the length and intensity of heatwaves may cause small numbers of additional deaths in summer, while warmer weather may produce some reduction in winter death rates. Those most affected will be the aged and chronically ill.

Respiratory illness

Potential indirect health impacts include increased illness due to allergens and air pollution. One condition receiving particular attention is asthma, a growing problem in Australia, now affecting

about one in four children and one in ten adults. The total cost of asthma in New South Wales was estimated in 1991 at more than \$200 million. Research includes the development of an integrated environmental model that should improve understanding of the role of climatic factors in initiating asthma attacks. A review of the potential effects of climate change on Australian plants that produce pollen causing allergy problems concluded that allergenic cases are likely to become significantly more frequent with global warming. Findings from research on photochemical smog in Melbourne suggest that climate change will increase peak pollution levels and may result in more frequent major smog episodes.

Vector-borne diseases

Increased mosquito numbers, resulting from increased flooding and rising sea levels with greater tidal penetration of coastlines, may result in a greater and more widespread incidence of diseases – such as Australian encephalitis, Ross River fever and dengue – spread by mosquitoes. In addition, higher temperatures are likely to mean the insects will become infectious more quickly after ingesting virus, increasing the risk that they will infect people who come in contact with them. Mosquitoes that spread Australian encephalitis and Ross River virus are present throughout Australia, but the species that carries dengue is usually found only in Queensland. Climate change may result in it extending its range west to the Northern Territory and south to New South Wales.

Malaria is another concern. Australia has been malaria-free since 1962 despite having mosquito species that can spread the disease and temperatures in the north high enough for the protozoan parasites that cause it. The risk exists that, with increased mosquito breeding and an expansion of the area suited to the parasites as temperatures rise further, malaria will reappear.

Infrastructure

Increased requirements

Climate change could necessitate major increases in spending on infrastructure such as dams, drainage systems and coastal works. In some cases, existing infrastructure will have design features that will enable it to cope with any changed conditions, but in many others substantial additions and reinforcements to existing structures or new infrastructure may be required.

Increases in the intensity and frequency of extreme rainfall events would be responsible for much of any additional infrastructure requirement. Augmentation of sewage and stormwater systems may be necessary in many cities and towns. New works could be needed to contain floodwaters, and at the same time larger dams may be required in some areas to maintain water supplies during longer dry periods. Additional spending would be required on road, railway and bridge repairs following floods.

Urban flooding

Research has begun on quantifying the implications of changes in the occurrence of extreme weather events for cities and towns. One study has examined the effects of climate change on flooding for several Australian urban communities. It found that under the wettest climate change scenario – combining the maximum increase in precipitation with the least warming – changes in flood frequency could be expected to become more pronounced beyond 2030. Extreme (1 in 100 years under current conditions) floods were estimated to become considerably more frequent by 2070. For example, such a flood might recur each 35 years in the Hawkesbury–Nepean region near Sydney and each 10 years for Queanbeyan and Canberra. These areas are representative of moderately populated river catchments in Australia. Average annual direct damage costs for the year 2070 from flooding in these communities were estimated to be 2.5 to 10 times higher than mid-1996 figures, with a corresponding increase in annual insurance premiums.



Coastal impacts

Coastal infrastructure will be affected by any significant rise in sea levels and potential increases in the frequency and intensity of storms. Major capital works may be needed to protect waterfront buildings, marinas, ports, industries situated near coastlines, beaches and holiday resorts. As described earlier, Australian researchers have made important contributions to the development and testing of methodology for coastal vulnerability assessment. This will play a key role in identifying hazards and developing appropriate responses.

Insurance

Expectations of increased coastal property damage due to rises in sea levels, increased storm surge activity and, in the north, a possible increase in maximum 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.

Losses caused by flood, fire and storm events can be very large; recent examples include insured losses of more than \$150 million in New South Wales bushfires in 1994 and \$200 million in floods in Victoria and New South Wales the previous year. 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.

A number of impact studies are being conducted in collaboration with insurance companies. One early finding is that climatic effects are the most significant factor in insurance claims from the agriculture sector. A modelling study has projected significant changes in hail losses to winter cereals in the grain belt of New South Wales as a result of global warming. A high proportion of these crops are regularly insured for hail damage. A major new study is investigating possible impacts on society of the insurance industry's responses to increased flood and bushfire damage following climate change.

Tourism

The potential damage to Australia's tourist industry due to climate change could have substantial economic implications. Statistics for 1993/94 show that tourism accounted for 6.6% of gross domestic product and foreign exchange earnings of more than \$10 billion, 12% of Australia's total current account credits. 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.

Research has been conducted on possible losses of snow cover and their impact on tourism in alpine regions. One study projected a reduction of more than half in snow duration at two moderate to lower elevation resorts in Victoria following a 1°C warming, with smaller but still substantial reductions at higher resorts. The findings suggest that the ski industry will need to adapt to remain viable.

ADAPTATION

It is clear that climate change may have substantial impacts on Australia, with all sections of the community potentially affected. While many effects will be adverse, others will be favourable. Adaptation strategies are being developed, and more of these will need to be implemented to minimise the risks and take advantage of the opportunities of climate change.

Findings from climate change impacts research form the basis of adaptation strategies, but the continuing large degree of uncertainty about what will happen is a barrier to strategy development. Difficulties also arise because climate change is only one of many changes to which people need to adapt, the need for adaptive responses to climate change is not yet widely accepted, and a range of poorly understood institutional and behavioural barriers to adaptation still exist. Nevertheless, recognition is growing of the importance of effective adaptation strategies.

National Greenhouse Strategy

The 1992 National Greenhouse Strategy aims to 'protect Australia's natural, human and built environment from the potential impacts of the enhanced greenhouse effect'. As mentioned in the Preface to this communication, the Strategy is currently under review, and outcomes will be published in a supplement.

Management tools and measures

Many projects currently given strong support in Australia are highly relevant to climate change adaptation. For example, the extensive tree planting being undertaken to counter soil salinisation and erosion will help prevent the projected worsening of these problems due to climate change. Decision support systems that are being developed to help farmers and graziers manage climate variability will also assist them in responding to climate change. The continued development of improved crop and pasture plant cultivars will expand the options available as atmospheric CO₂ levels rise and temperature and rainfall regimes change.

Various software packages developed recently are useful tools for researchers and land managers. One of these, *Ozclim*, generates climate change scenarios and simulates potential impacts of climate change in Australia. It has the capacity to 'plug in' a range of impact models, allowing exploration of the sensitivity of impacts to different global warming scenarios. Another package, *Australian Rainman*, is useful as a management tool to estimate the probability of rainfall at a regional level based on previous records and existing climate variability.

State and Local Government initiatives

Various initiatives that specifically address impacts of global warming have been undertaken by State and Local Governments. For example, South Australian Government planning principles now require that coastal developments be safe for a 30 centimetre rise in sea level, or one metre in special circumstances. Developments must also be safe for, or capable of being protected against, 100 years of coastal erosion, with allowance made for the erosion resulting from a sea level rise of 30 centimetres. In New South Wales, the National Parks and Wildlife Service has developed a biodiversity strategy that recognises the potential role of environmentally managed 'corridors' in enabling species migration in response to climate change.

An example of action by Local Government is the development of a greenhouse strategy by the Southern Sydney Regional Organisation of Councils. This recommends that the organisation's eleven member councils adopt a minimum design level for coastal and tidal structures taking into account potential rises in sea level and increased storm surge risk. Other recommendations include restricting development on low lying areas likely to be affected by sea level rise, monitoring research on sea levels and adjusting policy accordingly, and reviewing design standards for stormwater drains to ensure that they can cope with predicted future conditions.



Many current measures to protect human health – such as programs to reduce smog levels in cities and monitor the spread of arthropod-borne diseases – would become increasingly important if climate change were to raise hazard levels.

Research

Scientific research will play a vital role in facilitating adaptation. In some cases an extension of existing work will be needed; for example, agricultural research that is broadening farmers' options under current conditions will help provide them with the means to adapt to climate change. Research that specifically addresses adaptation issues is also required.

Australian researchers have developed a methodological framework for identifying adaptation policy responses to climate change. This involves an integrative assessment process that facilitates development of both mitigation and response measures. Adaptation was a major focus of the nine case studies conducted during 1994 and 1995 as part of the development of coastal vulnerability assessment methodology. Goals of those studies included developing means to enhance the ability of Australian governments to incorporate vulnerability assessment into integrated coastal zone management policy processes and practices.

In the past two years, Australian scientists have begun to develop a more integrated approach to impacts assessment. One major study, mentioned earlier, examined the impact of climate change on river-flow in the Macquarie River Basin, and the associated changes to the regional economy including impacts on grazing and cropping industries. An issue that was highlighted was that climate change may reduce river-flow, requiring adjustments to the water allocations for industry and environmental flows in the region. Other integrated studies include an assessment of the socio-economic effects of the impacts of climate change on the cattle tick.

In recognition of the importance of integrating the findings of research focused on particular sectors and coordinating research efforts, an impacts and adaptation liaison project is under way.

Financial assistance and technology transfer

INTRODUCTION

The Australian Government, through the Australian Agency for International Development (AusAID), provides assistance for activities in developing countries – particularly in the Asia-Pacific region – which support the objectives of the Convention. The purpose of the aid program managed by AusAID is to help developing countries reduce poverty and improve the standard of living of their people through sustainable development. Other government departments and agencies also assist developing countries to address the global climate change challenge.

FINANCIAL RESOURCES FOR MEETING THE COSTS OF MEASURES (ARTICLE 4.3)

In 1995/96, the aid program supported bilateral and regional projects valued at about A\$90 million which directly contribute to greenhouse gas reductions. The aid program also supports a wide range of projects for better management in sectors such as energy, forests, land resources and the environment which indirectly enhance the ability of developing countries to address climate change issues.

Contribution to the Global Environment Facility

Australia contributes to the GEF, the entity operating the financial mechanism of the Convention on an interim basis. Established in 1991, the GEF provides grant funds to developing countries for projects and activities which aim to protect the global environment by combating climate change, as well as conserving biodiversity, protecting international waters and reducing depletion of the ozone layer. In accordance with guidance from Conferences of the Parties to the Convention, the GEF channels funds provided by Parties in compliance with their obligations under Articles 4.3 and 4.1.

Australia has committed A\$72.76 million to the GEF. This comprises contributions of A\$30 million to the GEF pilot phase (1991 to 1994), including co-financing of the Thailand Energy Efficiency Project (see box), and A\$42.76 million to the replenishment of the GEF for 1994 to 1997.

Thailand Energy Efficiency Project

This US\$250 million GEF climate change project is implemented by the World Bank. It comprises a five-year demand side management plan (1993 to 1998), which is building institutional capability in the Thai electric power sector and throughout the Thai economy. Australia has committed A\$8.5 million as co-financing to the project.

As a result of the project, lighting equipment manufacturers are replacing production of fluorescent tubes with high efficiency lamps. The Electricity Generating Authority of Thailand has launched a High Efficiency Refrigeration Program targeting residential sales. Programs focusing on developing load research capability, new commercial building designs, industrial motor efficiency improvement, and demand side management training have been started. The project demonstrates potential financial and environmental savings through reducing the use of fossil fuels for energy production.

Other multilateral assistance

In addition to its contribution to the GEF, Australia provides funding to other multilateral organisations that assist in funding climate change activities. With strong support from donors, including Australia, organisations such as the World Bank, the Asian Development Bank and the United Nations Development Programme are giving increased emphasis to climate change issues. For example, the World Bank has launched a Solar Initiative to hasten the commercialisation of solar and other renewable energy technologies and significantly expand their applications in developing countries.

Framework Convention on Climate Change

In accordance with its obligations, Australia has made timely annual contributions toward supporting the budget of the Convention. For 1995, 1996 and 1997 the total contribution, made through Environment Australia's Climate Change Program, was A\$337 000.

Intergovernmental Panel on Climate Change (IPCC)

As part of the same Climate Change Program, Australia provides substantial funding to the IPCC for a range of activities, including participation by developing countries at IPCC meetings and workshops and capacity building activities. For 1995, 1996 and 1997 this assistance totalled A\$315 000.

Assistance to vulnerable small island States in the Pacific

Developing countries would be particularly vulnerable to the potential adverse effects of climate change. Low lying areas – including small island nations – would face the risks of sea level rise, loss of freshwater aquifers, and increased frequency and severity of extreme weather events such as storms and hurricanes. People living in poverty on marginal subsistence lands with little or no infrastructural support would be particularly vulnerable to adverse effects such as droughts, floods and cyclones.

Australia has integrated environmental concerns into its development assistance to the Pacific. Projects in the Pacific that contribute directly to climate change mitigation and adaptation include:

- *the National Forestry and Conservation Action Program Trust Fund* (A\$7.2 million), which aims to assist the forest sector in Papua New Guinea. The activities supported under the Fund include community conservation, landowner awareness and afforestation. In addition to promoting sustainable forestry, the project will assist in the reduction of greenhouse gas emissions by enhancing carbon sinks.
- *a Pacific Islands Forests and Trees Support Program*, to which Australia is providing A\$600 000 over a period of three years. This project will enhance carbon sinks, resulting in reduced net greenhouse gas emissions.
- *the Sea Level and Climate Monitoring Project*. Under this project (A\$13.5 million), Australia has helped install eleven sea-level monitoring stations throughout the Pacific and developed systems to collect and analyse the data they gather. This information has already yielded benefits for Pacific Island countries in predicting exceptional climatic events. The project also aims to raise awareness of climate change effects and provide training to deal with them (see box below).
- *the South Pacific Forum Secretariat's Energy Program*. Australia supports this program, which has been effective in promoting the adoption of energy-efficient policies and renewable energy technologies.
- *the Provincial Rural Renewable Energy Electrification System in the Solomon Islands*. Australia provided funding of A\$237 300 to the Australian non-government organisation Appropriate Technology for Community and Environment to help implement this project, which will reduce greenhouse emissions through improved fuel efficiency.

Australia belongs to, and strongly supports, the South Pacific Regional Environment Programme (SPREP), the peak environment organisation in the South Pacific. Based in Samoa, SPREP helps Pacific Island countries, including Papua New Guinea, and Pacific territories to deal with crucial environmental and natural resource management issues, including climate change. Australia contributed A\$1.2 million to SPREP in 1995/96, and in 1996/97, and is its largest bilateral donor.

Pacific Sea Level and Climate Monitoring Project

Pacific Island leaders have long been concerned about the potential effect of climate change and sea level rise on their countries. Australia responded positively to these concerns by funding the Sea Level and Climate Monitoring Project in partnership with Pacific Island Governments.

During Phase I, from 1989 to 1995, the project installed eleven sea level monitoring stations around the Pacific and developed advanced computer databases to collect, store and analyse the data from the stations. Regional training workshops raised awareness of sea level rise and its potential implications for Pacific Island Countries (PICs). The total cost of Phase I was A\$7.5 million.

Phase II of the project, which will run for five years at a cost of A\$6 million, commenced in July 1995. Its aims cover increased awareness, training, and the provision of accurate and timely advice to PICs on changes in sea level, storm surges and possible climate change effects on individual countries. This phase also funds the climate change officer in SPREP, who has a significant role in training.

PICs are already using data from this project to devise vulnerability studies and approaches to integrated coastal zone management.

SPREP's 1997–2000 Action Plan, which Australia as a SPREP member helped formulate, identifies climate change as one of five focal areas on which it will concentrate until the end of the century. SPREP's climate change program brings together in a coordinated way the many national, bilateral, regional and multilateral efforts in climate change in the South Pacific.

SPREP has also coordinated and assisted in the preparation of National Environmental Management Strategies throughout the region, with financial and technical assistance from Australia. As a result, each PIC has, in a regionally consistent format, a top-level environmental strategy which assesses the environmental challenges it faces and the capacity of the nation to cope with them.

FINANCIAL RESOURCES FOR MEETING COSTS OF ADAPTATION (ARTICLE 4.4)

In line with Article 4.4 of the Convention, Australia is assisting developing countries to prepare for adaptation to climate change through support for planning activities. Some examples include the following:

- SPREP is coordinating a series of vulnerability studies, partly funded by Australia, with a view to developing plans for adaptation to the possible adverse effects of climate change.
- The South Pacific Applied Geoscience Commission (SOPAC), which is supported financially by Australia (A\$720 000 in 1995/96), has assisted with studies of vulnerability to erosion in Fiji and Kiribati, and has run in-country seminars on coastal monitoring in Tuvalu, Kiribati and Samoa.
- With Australian assistance, initial work began in 1995/96 on a bilateral project with Tonga which aims to improve the monitoring and planning capacity of the environment unit of Tonga's Ministry of Lands, Survey and Natural Resources.



MEASURES TO PROMOTE, FACILITATE AND FINANCE ACCESS TO, OR TRANSFER OF, ENVIRONMENTALLY SOUND TECHNOLOGIES (ARTICLE 4.5)

Australia has learnt that the transfer of 'hard' technology (eg. equipment, plant, hardware) will only be effective if it is accompanied by appropriate soft technology to build countries' capacities to maximise and sustain the benefits of the hard technology. Australia recognises the importance of close consultation with the domestic business, scientific and environmental communities as a mechanism for increasing its focus on, and capacity for, technology transfer to developing countries.

'Hard' technology

Lessons learnt by Australia from the successful use of renewable energy technologies in remote locations in central and northern Australia can be readily adapted to the needs of economies in the Asia-Pacific region. Many Australian firms can supply equipment that embodies the latest advances in technologies such as photovoltaic electricity production, solar generation of heat and biomass combustion. Using this expertise, AusAID has implemented renewable energy projects in developing countries, such as the Municipal Solar Infrastructure Project in the Philippines (see box).

Municipal Solar Infrastructure Project - the Philippines

One thousand photovoltaic (solar-powered) electricity generators will be installed in 387 barangays (local community areas) in the Philippines in this \$37 million project. AusAID's contribution is \$13.2 million. The target communities are located in some of the poorest provinces of the country. Installation of the units is scheduled to start in October 1997 and is expected to be completed by mid 2000.

The systems will be installed at health centres, municipal halls, schools and water supply facilities to provide electricity for basic services such as lighting, refrigeration (eg. for vaccines), communications, ceiling fans, small appliances and water pumping. They will reduce the communities' dependence on non-renewable energy sources such as oil, and help reduce deforestation by reducing demand for fuelwood.

The benefits of the project are expected to include: an improvement in the livelihood of the target communities; a reduction in local air and noise pollution; improved water supplies; better health and education facilities; and an improvement in the welfare of women and children through freeing time spent on food and water collection and reducing indoor pollution from the burning of biomass fuels.

By comparison, if diesel generators were used to provide the same levels of power, carbon dioxide emissions would increase by approximately 10 900 tonnes over the life of the project. Another long-term benefit of the project will come from demonstrating the substantial contribution that solar energy can make to social and economic development.

Other Australian projects include the following:

- Funding of A\$50 000 was provided for the installation of solar powered water heaters with electrical back-up to reduce electricity costs and ensure a continuous hot water supply at the Nyanga District Hospital, Zimbabwe.
- Australia funded, through a A\$600 000 grant, a pilot project to supply and install photovoltaic cells in 1000 homes in the village of Pansiyagama, Sri Lanka. These cells power lights and small electrical appliances.
- Under the ASEAN-Australia Economic Cooperation Program Phase III, which Australia supports with a A\$4 million contribution, ASEAN countries are developing commercial fluidised bed combustion technologies for the production of combined heat and power. These utilise biomass residue from industry.

Henan/Yima Coal Gasification Project – hard and soft technology transfer working together

More than 500 000 households and millions of people in Henan Province, China, are expected to benefit from the modern coal gasification plant supplied by this Australian joint venture. AusAID has provided approximately A\$29 million as part of a concessional finance package totalling A\$85.5 million.

The gasification plant is only one part of the overall development, which will also see a pipeline and municipal gas distribution network built to link the four major municipalities in Henan Province.

The Australian involvement in the project includes providing both the ‘hard technology’ and the ‘soft technology’. The hard technology includes the fuel oil recovery unit, fluidised bed boilers and spare parts. The soft technology includes: designing the processes; providing skilled supervisors and advisers during the installation, commissioning and testing of the plant; training the operators; and assisting the preparation of, and training for, technical documentation.

The plant converts steaming grade coal into town gas, which will replace the direct burning of coal in homes. This has been one of the major causes of air pollution in the region, both indoors and outdoors. Replacing coal with coal gas as the major source of domestic energy will dramatically reduce levels of particles and sulphur dioxide in the atmosphere. The current levels have caused health problems in the region.

‘Soft’ technology

Capacity building is intrinsic to Australia’s development cooperation program across all sectors. It includes education and training, workshops and conferences, institution strengthening, technical assistance and collaborative research.

Education and training

A significant proportion of Australia’s overseas aid program is provided through training. In 1996, approximately 750 students were studying subjects related to environmental issues, and a number of these courses have elements pertaining to climate change. For example, under the Coal Technology Training Program for Asia, Australia is providing \$2.2 million from 1995 to 1997 to transfer the technical and managerial skills needed to use coal cleanly and efficiently. In addition, in 1995 and 1996 AusAID sponsored 20 students to undertake a UNEP-supported Graduate Certificate in Environmental Management, facets of which include climate change issues.

Workshops and conferences

The aid program provides support for developing country representatives to attend renewable energy conferences, such as:

- International Symposium on Energy, Environment and Economics (held in Melbourne in November 1995);
- International Workshop on Solar Power Modelling and Applications (held in Perth in October 1995); and
- Solar 96: Energy for Life Conference (held in Darwin in October 1996).

Institutional strengthening

A particular example of this is the Climate Impact Assessment and Management Program for Commonwealth Countries. It aims to highlight the importance of scientifically measuring the impact of climate change, and to ensure that countries have the necessary technology to do this. All countries involved in the program work collaboratively with scientific organisations in other countries,



contributing to global knowledge and understanding of bioclimatology. Australia's contribution to the project was A\$3 million.

Through funding a climate change scientist at SPREP, in association with the Pacific Sea Level and Climate Monitoring Project, Australia is facilitating the strengthening of that institution's capacity in climate change matters.

Technical assistance

Australia assisted in the establishment of the Global Change and Terrestrial Ecosystems South East Asian Regional Centre. This Centre assists scientists to predict the effects of changes in climate, atmospheric composition and land use on terrestrial ecosystems. It also helps to determine how these effects lead to feedback to the atmosphere and the physical climate system. Australia will provide approximately A\$2.6 million for the Centre over the three years 1995 to 1998. The Centre will serve as a resource base of scientific expertise and data, and analytical and interpretative skills, for ASEAN countries.

International Centre for Application of Solar Energy (CASE)

CASE is a joint initiative of the Western Australian and Commonwealth Governments to promote and facilitate the sustainable use of solar and renewable energy in developing countries, in conjunction with the United Nations Industrial Development Organisation (UNIDO).

CASE has concentrated its activities on isolated rural communities with limited or no access to electric power. Inaccessibility to national electricity grids makes these communities appropriate for renewable energy installations.

Services provided include: carrying out externally funded project definition studies; arranging for consultants to carry out feasibility studies; assisting in preparing applications for project finance; organising contractors to implement projects; managing projects; and ensuring local people are trained to operate and maintain renewable energy systems.

Climate Technology Initiative

Australia is a participant in the FCCC's Climate Technology Initiative (CTI), established in April 1995. The CTI is a linked set of practical national and international measures which aim to identify and share expertise and experiences between countries on greenhouse abatement technologies.

Australia has contributed to a CTI Inventory of Activities which describes relevant national and multilateral activities, already initiated by OECD/IEA member countries, that can address climate change concerns.

Collaborative research

The Australian Centre for International Agricultural Research (ACIAR) has developed collaborative research programs to assist partner countries to identify and solve their major agricultural problems, and at the same time strengthen their own research capacity, including in areas associated with climate change. Over the period 1994 to 1996, ACIAR provided funding of approximately A\$2.8 million to international agricultural research centres which conduct research of particular relevance to climate change. Support totalling A\$1.4 million was directed to the Centre for International Forestry Research, and approximately A\$600 000 to the International Centre for Research in Agroforestry, to assist their programs which have a positive effect on greenhouse gas sequestration. In addition, through its A\$1.5 million contribution to the International Board for Soils Research and Management, ACIAR supported a range of adaptive research projects which aim to decrease forest clearing or to increase sequestration of carbon in soil organic matter.

ACTIVITIES IMPLEMENTED JOINTLY (AIJ)

Under Article 4.2 (a) of the Convention, there is provision for countries to meet their greenhouse gas abatement obligations jointly with other Parties to the Convention. Joint implementation is expected to allow the Parties to meet future greenhouse commitments in a more efficient and cost-effective manner than if they acted alone. At the joint implementation stage, investing countries are expected to be able to claim credits for greenhouse gas abatement, as part of fulfilling international commitments.

As a forerunner to joint implementation, a pilot phase – referred to as Activities Implemented Jointly (AIJ) – is being implemented providing opportunities for countries to cooperate to reduce, avoid or sequester greenhouse gas emissions.

Australia's AIJ initiative, which involves industry and government, is referred to as International Greenhouse Partnerships and complements a domestic program called Greenhouse Challenge. Greenhouse Challenge is establishing voluntary cooperative agreements between industry and government, and has already proved highly effective in encouraging industry to devise and implement cost-effective measures to mitigate greenhouse gas emissions in Australia.

Australia considers that International Greenhouse Partnerships provide a significant means to limit greenhouse gas emissions through voluntary, cost-effective and commercially viable actions at the international level. Successful implementation of AIJ projects will be an important consideration in the scheduled international review of the pilot phase.

Australia, following guidance from the FCCC, adopts three basic criteria which AIJ projects must satisfy. These are:

- Endorsement by the participating countries. Endorsements must indicate that proposals recognise the host countries' social and economic conditions and are compatible with and supportive of their environment and development priorities.
- Measurability and additionality (to business-as-usual) of emissions reduced or sequestered. AIJ projects should lead to real and measurable emission reductions, determined against agreed baselines.
- Additionality of project finance. Financing of AIJ projects must be additional to existing levels of official development assistance (ODA) and other financial assistance under the FCCC.

The Australian Government is facilitating International Greenhouse Partnerships through several initiatives. In October 1996 it established the AIJ Australia Office, which is a 'one-stop shop' to Australian Government advice and support services. The role of this office is to: identify and progress projects which satisfy AIJ criteria and guidelines; assist with negotiating project agreements; and help with linkages between financing organisations and domestic and international entities.

The Prime Minister's package of strengthened measures, announced on 20 November 1997, include additional funding for the AIJ office. This will help meet the additional transaction costs incurred by businesses undertaking an AIJ project, providing Australian industry with a greater incentive to undertake such projects.

Australia is also developing bilateral AIJ arrangements with potential host countries willing to cooperate on AIJ. A Joint Statement of Intent was signed with Indonesia in October 1996. Australian industry and government are working closely to promote AIJ with other willing countries and their industry. Promotion will incorporate business sector linkages through workshops or sectorally focused missions, and assist with the generation of mutually beneficial project proposals.



An example of activities undertaken by the AJJ Australia Office to support the development of Australian AJJ projects is the AJJ workshop staged jointly with the Indonesian Ministry of State for Environment in Jakarta on 2-3 July 1997. This workshop was attended by representatives of Australian business enterprises and Indonesian Government agencies and industries. The workshop was successful in identifying AJJ opportunities in energy efficiency, renewable energy and forestry. Specific AJJ projects are under consideration.

In Indonesia the AJJ Australia Office is also keen to strengthen institutional relationships and assist with capacity building during the pilot phase. This emphasis is reflected in the first cooperative project, which concentrates on training in the renewable energy area and involves a small scale renewable energy demonstration. At the demonstration stage, the project will be eligible for AJJ status, subject to agreements being reached on baselines and also on estimating, monitoring and reporting on greenhouse gas reduction.

Present Australian project activities

Australia is currently undertaking two small-scale AJJ projects in the South Pacific Region. These are:

- A grid connected photovoltaic project in the Republic of Fiji. The energy produced by the solar photovoltaic power system will largely displace diesel power.
- An air conditioner efficiency project in the Solomon Islands. This project focuses on the promotion of energy conservation awareness, improved air conditioner maintenance and the use of timer controls for air conditioner operation.

The South Pacific Forum Secretariat has been contracted to administer and oversee the implementation of the projects. The main project costs are being borne by the Australian Government, with some in-kind contributions from host country agencies directly involved in project implementation.

Table 7.1 Financial contributions to the operating entity or entities of the financial mechanism, regional and other multilateral institutions and programs.

US\$(¹)	1994/95	1995/96
Global Environment Facility	\$6,761,730	\$3,392,700
Multilateral institutions		
International Fund for Agricultural Development	\$1,701,898	\$130,185
Asian Development Bank - ADF	\$31,043,994	\$64,080,213
- OCR		\$637,964
World Bank - IDA	\$89,265,093	\$86,715,045
- IBRD		\$0
International Finance Corporation		\$0
European Bank for Reconstruction and Development	\$7,653,300	\$2,288,100
United Nations Development Programme	\$14,123,100	\$14,596,500
International Union for the Conservation of Nature	\$231,177	\$78,900
United Nations Environment Programme	\$893,148	\$867,900
Tropical Marine Ecosystem Program	\$219,342	\$36,120
International Tropical Timber Organisation	\$239,810	\$189,360
Intergovernmental Panel on Climate Change	\$78,900	\$0
South Pacific Regional Environment Programme	\$931,020	\$1,107,743
International Atomic Energy Agency	\$4,851,561	\$1,017,810
Commonwealth Bioclimatology Programs		\$0
Other: -		
United Nations Development Agencies	\$26,160,084	\$7,925,500
Emergency and Refugee Organisations	\$60,545,493	\$39,186,771
International Environment Programs	\$3,260,937	\$3,020,687
Commonwealth Development Organisations	\$8,693,991	\$8,033,302
Other Multilateral Agencies	\$5,217,657	\$0
International Health and Population Programs	\$13,120,281	\$7,955,037
Asia/Pacific Regional Agencies	\$7,254,066	\$8,291,614
Multilateral scientific programs		
International Rice Research Institute	\$749,550	\$740,082
Centre for International Forestry Research	\$118,350	\$249,300
International Board for Soils Research & Management	\$365,307	\$422,115
International Centre for Research in Agroforestry	\$407,124	\$355,050
Multilateral technology programs		
United Nations Industrial Development Organisation	\$2,461,680	\$1,577,989
Multilateral training programs		
UNEP Graduate Certificate in Environmental Management for Sustainable Development	\$126,240	\$129,396
TOTAL	\$286,474,833	\$253,025,383

1. 1995/96 Constant Prices

The average annual exchange rate of 0.7890, provided by the Australian Bureau of Statistics, has been used to convert Australian dollars to US dollars.



Table 7.2 Bilateral financial contributions related to the implementation of the Convention for the financial year 1994/95.⁽¹⁾

Recipient Country	US\$(²)						Total
	Mitigation			Adaptation		Other (³)	
	Energy	Forestry	Agriculture	Waste Management			
PNG	\$0	\$36,623	\$81,204	\$0	\$0	\$0	\$117,826
Oceania	\$0	\$0	\$0	\$0	\$0	\$1,763,475	\$1,763,475
Solomon Islands	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Pacific Islands	\$0	\$0	\$0	\$0	\$0	\$0	\$0
South East Asia Region	\$0	\$33,721	\$0	\$0	\$0	\$266,230	\$299,952
Indonesia	\$29,127	\$23,437	\$303,067	\$0	\$0	\$0	\$355,631
Philippines	\$0	\$89,822	\$568,426	\$0	\$0	\$0	\$658,247
Thailand	\$0	\$0	\$541,357	\$0	\$0	\$0	\$541,357
Malaysia	\$0	\$0	\$54,135	\$0	\$0	\$0	\$54,135
Vietnam	\$0	\$353,468	\$189,475	\$0	\$0	\$0	\$542,943
Cambodia	\$31,669	\$36,542	\$0	\$0	\$0	\$0	\$68,211
Laos	\$142,399	\$51,332	\$0	\$0	\$0	\$0	\$193,731
China	\$5,245,524	\$61,607	\$607,430	\$0	\$0	\$0	\$5,914,560
ASEAN	\$242,620	\$0	\$0	\$0	\$0	\$0	\$242,620
India	\$198,582	\$0	\$54,135	\$0	\$0	\$0	\$252,717
Nepal	\$0	\$1,665,117	\$0	\$0	\$0	\$0	\$1,665,117
Bangladesh	\$99,373	\$0	\$0	\$0	\$0	\$0	\$99,373
Sri Lanka	\$0	\$1,253,890	\$0	\$0	\$0	\$0	\$1,253,890
Pakistan	\$30,451	\$0	\$189,475	\$0	\$0	\$0	\$219,926
Maldives	\$0	\$801	\$0	\$0	\$0	\$0	\$801
Eritrea	\$0	\$24,361	\$0	\$0	\$0	\$0	\$24,361
Ethiopia	\$0	\$168,195	\$0	\$0	\$0	\$0	\$168,195
Kenya	\$0	\$11,282	\$0	\$0	\$0	\$0	\$11,282
Malawi	\$0	\$54,609	\$0	\$0	\$0	\$0	\$54,609
Ecqador	\$64,122	\$0	\$0	\$0	\$0	\$0	\$64,122
Uganda	\$0	\$0	\$31,203	\$0	\$0	\$0	\$31,203
Africa Regional	\$0	\$174,425	\$189,475	\$0	\$0	\$0	\$363,900
Global	\$3,167	\$0	\$0	\$0	\$0	\$7,746	\$10,913
TOTAL	\$6,087,035	\$4,039,234	\$2,809,382	\$0	\$0	\$2,037,452	\$14,973,101

1. The Australian financial year is the period 1 July to 30 June.

2. 1995/6 Constant Prices

The average annual exchange rate of 0.7890, provided by the Australian Bureau of Statistics, has been used to convert Australian dollars to US dollars.

3. The figures in the column "Other" reflect expenditure on projects which are not readily classified elsewhere.

Table 7.2 (continued) Bilateral financial contributions related to the implementation of the Convention for the financial year 1995/96.⁽¹⁾

Recipient Country	US\$(²)				Adaptation	Other (³)	Total
	Mitigation		Waste Management				
	Energy	Forestry	Agriculture				
PNG	\$0	\$78,900	\$78,900	\$0	\$0	\$1,642,784	\$1,800,584
Oceania	\$0	\$0	\$0	\$0	\$0	\$1,523,541	\$1,523,541
Tonga	\$0	\$67,460	\$0	\$0	\$0	\$0	\$67,460
Solomon Is	\$85,054	\$27,802	\$0	\$0	\$0	\$0	\$112,856
Vanuatu	\$0	\$3,945	\$0	\$0	\$0	\$0	\$3,945
Pacific Islands	\$0	\$0	\$0	\$0	\$568,080	\$31,422	\$599,502
South East Asia Region	\$0	\$173,933	\$0	\$0	\$0	\$787,928	\$961,861
ASEAN	\$309,825	\$0	\$0	\$0	\$0	\$0	\$309,825
Indonesia	\$0	\$9,764	\$289,299	\$22,191	\$0	\$0	\$321,254
Philippines	\$0	\$560,622	\$552,300	\$0	\$0	\$0	\$1,112,922
Malaysia	\$0	\$0	\$52,599	\$0	\$0	\$0	\$52,599
Thailand	\$0	\$103,108	\$546,582	\$35,767	\$0	\$0	\$685,457
Vietnam	\$11,156	\$306,556	\$184,100	\$0	\$0	\$0	\$501,812
Cambodia	\$0	\$48,800	\$0	\$0	\$0	\$0	\$48,800
Laos	\$401,590	\$0	\$0	\$0	\$0	\$0	\$401,590
China	\$11,598	\$0	\$578,600	\$0	\$0	\$0	\$590,198
India	\$41,028	\$83,353	\$52,599	\$0	\$0	\$0	\$176,981
Nepal	\$10,296	\$2,094,595	\$0	\$0	\$0	\$0	\$2,104,891
Bangladesh	\$0	\$127,352	\$0	\$0	\$0	\$0	\$127,352
Sri Lanka	\$0	\$1,337,711	\$184,100	\$0	\$0	\$0	\$1,521,811
Eritrea	\$0	\$52,539	\$0	\$0	\$0	\$0	\$52,539
Zambia	\$0	\$28,735	\$0	\$0	\$0	\$0	\$28,735
Ethiopia	\$0	\$165,586	\$0	\$0	\$0	\$0	\$165,586
Kenya	\$5,930	\$5,744	\$0	\$0	\$0	\$0	\$11,674
Malawi	\$0	\$5,918	\$0	\$0	\$0	\$0	\$5,918
Uganda	\$0	\$62,418	\$0	\$0	\$0	\$0	\$62,418
Africa Regional	\$0	\$330,686	\$184,100	\$0	\$0	\$0	\$514,786
Ecuador	\$0	\$70,371	\$0	\$0	\$0	\$0	\$70,371
Nicaragua	\$0	\$8,557	\$0	\$0	\$0	\$0	\$8,557
Zimbabwe	\$59,175	\$0	\$0	\$0	\$0	\$0	\$59,175
Global	\$18,171	\$5,176	\$0	\$5,681	\$0	\$41,020	\$70,047
TOTAL	\$953,824	\$5,759,629	\$2,703,179	\$63,638	\$568,080	\$4,026,695	\$14,075,045

1. The Australian financial year is the period 1 July to 30 June.

2. The average annual exchange rate of 0.7890, provided by the Australian Bureau of Statistics, has been used to convert Australian dollars to US dollars.

3. The figures in the column "Other" reflect expenditure on projects which are not readily classified elsewhere.

Table 73 Examples of Australian aid projects or programs that promote, facilitate and/or finance transfer of access to “hard” technologies.

A Project/program title:	Henan/Yima Coal Gasification project		
Purpose:	To provide a cleaner and more greenhouse benign form of energy.		
Recipient Country	Sector	Total funding	Years in operation
Peoples Republic of China	Energy	A\$29,937,975	1994-1996
Description:	<p>The project will provide the people of the Henan Province in China with a modern coal gasification plant. It will replace the existing form of domestic energy source, coal.</p> <p>The gasification plant is only one part of the overall development, which will see a pipeline and municipal gas distribution network built to link the four major municipalities in the Henan province. The total cost of the joint venture concessional finance package is A\$85.5 million.</p> <p>The Australian involvement in the project includes providing: the fuel oil recovery unit; the fluidised bed boilers; designing the processes providing skilled supervisors and advisers during the installation; commissioning and testing of the plant; training the operators; technical documentation and providing spare parts.</p>		
Ministry:	Australian Agency for International Development (AusAID)		
Contact:	Director China and Central Asia Section		
Address:	GPO Box 887 Canberra ACT 2601 Australia		
Phone no:	61 2 6206 4800		
B Project/program title:	Huangshi Coal Gas Project Hebei Province		
Purpose:	To reduce the level of environmental pollution and thereby enhance health standards in the area, which are currently adversely affected by high levels of environmental pollution largely arising from coal burning activities.		
Recipient Country	Sector	Total funding	Years in operation
China	Energy	A\$2,934,783	1995-98
Description:	<p>The proposed gasification plant will supply coal gas for domestic and industrial use, approximately in the ratio of 3:1. The domestic service will provide gas for 60,000 households</p> <p>The cost of the project is estimated to be US\$13.5 million. AusAID will provide US\$2.2 million towards the gasification plant</p> <p>The coal gasification process to be installed is a 2-stage Wellman cyclic water gas plant of modern design. Engineering, site engineers and training will also be provided.</p> <p>The project will greatly improve both outdoor and indoor air quality in Huangshi, where gas will replace the direct burning of coal for domestic and industrial purposes. The project is consistent with the national gasification policy and will contribute to national air quality improvement policy, particularly through the reduction in particulates and sulphur dioxide to the atmosphere.</p>		
Ministry:	Australian Agency for International Development (AusAID)		
Contact:	Director China and Central Asia Section		
Address:	GPO Box 887 Canberra ACT 2601 Australia		
Phone no:	61 2 6206 4800		

C Project/program title: ASEAN - Australia Economic Cooperation Program Energy Biomass Residue

Purpose: To reduce emissions through a benign form of fuel usage, as well as to preserve the carbon sink.

Recipient Country/Region	Sector	Total funding	Years in operation
ASEAN	Energy	A\$3,000,000	1994-1998

Description: The project will assist ASEAN countries in the commercial development of fluidised bed combustion (FBC) technologies for the production of combined heat and power which utilises biomass residue.

The project aims to achieve environmentally-sound disposal of biomass residues and wastes; improve the viability of rural industries and their working environments; enhance the capability in the ASEAN countries to design, construct, install, operate and service FBC technology; and develop an industry to manufacture reliable, high efficiency steam engines for small-scale FBC CHP plants.

The project consists of the following components: project management; technology awareness; steam engine development; FBC demonstration; and training and commercialisation.

Ministry: Australian Agency for International Development (AusAID)
Contact: Director Business and East Asia Linkages Section
Address: GPO Box 887 Canberra ACT 2601 Australia
Phone no: 61 2 6206 4900

D Project/program title: Municipal Solar Infrastructure Project

Purpose: To supply electricity for health centres, water pumps, schools and community halls using greenhouse friendly solar technology.

Recipient Country/Region	Sector	Total funding	Years in operation
The Philippines	Energy	A\$13.2 million	1997-99

Description: One thousand photovoltaic (solar-powered) electricity generators will be installed at 387 barangays (local community areas) in the Philippines in this \$37 million project. AusAID's contribution is \$13.2 million. The target communities are located in some of the poorest provinces in the country.

The systems will be installed at health centres, municipal halls, schools and water supply facilities to provide electricity for basic services such as lighting, refrigeration (eg. for vaccines), communications, ceiling fans, small appliances and water pumping. They will reduce the communities' dependence on non-renewable energy services such as oil and fuelwood, as well as reducing deforestation.

The benefits of the project are expected to include: an improvement in the livelihood of the target communities; a reduction in local air and noise pollution; improved water supplies; better health and education facilities; and an improvement in the welfare of women and children by freeing time spent on food and water collection, and reduction of indoor pollution from the burning of biomass fuels.

By comparison, if diesel generators were used to provide the same levels of power, carbon dioxide emissions would increase by approximately 10,900 tonnes for the life of the project. Another long-term benefit of the project will come from demonstrating the substantial contribution that solar energy can make to social and economic development.

Ministry: Australian Agency for International Development (AusAID)
Contact: The Philippines Section
Address: GPO Box 887 Canberra ACT 2601 Australia
Phone no: 61 2 6206 4745





Research and systematic observation

INTRODUCTION

Australian scientists have been actively involved in climate, climate change and climate variability research for many decades. This commitment to research, combined with Australia's geographic location and size, mean that currently it has the most comprehensive research and monitoring activities related to climate change in the southern hemisphere. Australia and New Zealand are the only southern hemisphere nations that are Annex 1 Parties to the FCCC.

A large number of organisations - including universities, cooperative research centres and government agencies, particularly CSIRO and the Bureau of Meteorology - are involved in such research.

Environment Australia manages the National Greenhouse Research Program and the Government's Climate Change Program. These provide funding for greenhouse research, primarily by the Bureau of Meteorology and CSIRO but also by universities, Cooperative Research Centres and other research bodies.

The Department of Primary Industries and Energy (DPIE) also conducts or funds substantial climate and climate-related research and applications, and the development and implementation of strategies to respond and/or adapt to climate change and variability. The Antarctic Science Advisory Committee provides funding for high-latitude research, with climate change a priority area.

Coordination of scientific research with the major international climate and global change programs is carried out through the Australian Academy of Science's National Committee for Climate and Global Change.

The Bureau of Meteorology, a component of the Department of the Environment, operates Australia's national climate observation networks, and its National Climate Centre maintains as a computer and document archive Australia's climatological database. The Bureau of Meteorology Research Centre maintains a climate research program involving climate variability and change studies.

CSIRO's substantial research program encompasses atmospheric, oceanographic, hydrological and biospheric aspects of the climate system and a range of climate impact areas including agriculture and forestry. The focus for its climate-related activities is provided through two multi-divisional programs - on climate change and climate variability.

As the global climate system does not recognise national boundaries, the task of monitoring, understanding, and predicting the consequences of changes to the system requires cooperative and coordinated international action. Australia contributes to the international climate research effort through its direct participation in the activities of numerous programs, especially the World Climate Research Programme (WCRP).

DATA COLLECTION AND MONITORING

The primary responsibility for collecting and archiving national climate data rests with the Bureau of Meteorology. Substantial resources are invested in collecting a wide range of data both at the surface and from the upper atmosphere, and from across the continent and surrounding oceans. There are approximately 6200 active rainfall stations across Australia, 870 surface observation stations and 60 upper air stations. Additional surface observation networks, on considerably smaller geographical scales, are operated by various State and Territory agencies and CSIRO.

Scientists at the Bureau of Meteorology have identified a network of climate stations with long operational histories and high quality records. This network is critical to the detection of climate changes in Australia. It also provides important data sets used in the identification of global climate changes, and particularly those in the southern hemisphere.

Stratospheric ozone is monitored routinely at six stations around Australia, including one on Macquarie Island. A wide range of trace gas measurements are carried out; this work includes several long-term monitoring projects. One of these involves measurements of carbon isotope ratios to determine atmospheric sources and sinks for carbon, and another the measurement of carbon dioxide over the Southern Ocean using commercial aircraft. In order to monitor sea level around Australia, a national array of 16 tide gauges is maintained by the National Tidal Facility based at Flinders University.

Archives

The Bureau of Meteorology maintains the Australian meteorological data archive. This was upgraded recently into a modern on-line database system which allows researchers and policy makers ready access to Australian climate data. Data are also routinely published in the form of statistical analyses, climate atlases and monthly and annual climate summaries.

Australia's contribution to international data collection and monitoring programs is detailed in Table 8.1.

CLIMATE CHANGE RESEARCH

Climate processes

The Intergovernmental Panel on Climate Change (IPCC) has consistently pointed to the need for improved understanding of key climatic processes that will control aspects of climate change. Feedbacks associated with clouds, oceans, sea-ice and vegetation have been identified as important.

Australian scientists have contributed to understanding of climate processes and of global climate change, and participate in most of the major international research components of the World Climate Research Programme (WCRP) and in climate related activities under the International Geosphere-Biosphere Programme (IGBP). Australia has also been actively involved in work of the IPCC, including in the role of Vice-Chair.

Clouds and atmosphere

The Bureau of Meteorology, CSIRO, the CRC for Southern Hemisphere Meteorology and university departments such as the Flinders University Institute for Marine and Atmospheric Sciences have played very active roles in investigating atmospheric processes.

The Maritime Continent Thunderstorm Experiment (McTEX) conducted during the 1995/96 wet season examined the island convection over the maritime continent as part of the Global Energy and Water Cycle Experiment (GEWEX). The Southern Ocean Cloud Experiment, also part of GEWEX, was conducted in clean air to the north-west of Tasmania and focused on the role of cloud condensation nuclei from marine plankton in modifying cloud properties. This experiment, together with previous

work, confirmed that marine phytoplankton can change the properties of clouds, and hence influence radiation.

Australian scientists hosted the first phase of the Aerosol Characterisation Experiment, which compared aspects of atmospheric aerosols in the northern and southern hemispheres and was conducted in late 1995 and early 1996. This International Global Atmospheric Chemistry (IGAC) project aims to improve understanding of the influence of aerosols on climate, in order to more adequately represent their interaction with radiation in climate models.

Oceans

Australia has strongly supported investigations into the role of the oceans in the global climate system and how they may affect the rate and regional patterns of climate change. All Australian research in this field is integrated with the World Ocean Circulation Experiment (WOCE), the Tropical Oceans Global Atmosphere Experiment (TOGA), and the Joint Global Ocean Flux Study (JGOFS).

The Southern Ocean has been a major focus of attention for Australian scientists from CSIRO, the Antarctic CRC and the Australian Antarctic Division. The Southern Ocean is the world's only zonal ocean; as such, it not only plays a major role in the climate of the southern hemisphere but, by connecting with all the ocean basins, is important to the global system as a whole. Observations of this ocean are sparse, but are needed to validate the performance of global climate models used to predict climate change. The studies of the Southern Ocean have revealed systematic deficiencies in global model simulations for this region, and have provided new insights into the role of the Southern Ocean in the global carbon cycle.

Observations of the East Australian Current and the ocean circulation of the Tasman and Coral Seas are providing much-needed data for the verification of climate models in these regions.

Australian scientists have also been active contributors to tropical ocean programs. This work has resulted in a much clearer understanding of the El Niño–Southern Oscillation phenomenon. The Indonesian Through-flow, which provides an important oceanographic link between the Pacific and Indian Oceans, has been the subject of intensive investigations by both Australian and Indonesian scientists during the past few years.

Australia has also provided funding for upgrading the tide gauge network around Australia and at Antarctic and sub-Antarctic stations, and for installing tide gauges at a number of South Pacific islands.

Cryosphere (ice)

The Australian Government has maintained its strong commitment to research in the high latitudes, particularly the Antarctic. The impact of future climate change on the mass balance of the sub-Antarctic ice sheet, and the consequent implications for global sea-level rise, are being investigated under the Arctic Climate System Study (ACSYS) of the WCRP. Scientific research cruises into the Antarctic sea-ice zone play a critical role in elucidating the sea-ice and ocean processes identified by the IPCC as crucial to better understanding of future climate change. Australian scientists are also actively monitoring sea-ice in order to provide the baseline data necessary to determine the extent of future climate changes.

Australia has contributed to the ACSYS Antarctic Sea Ice Thickness Monitoring Programme through the supply of five upward looking sonar instruments installed near Casey station in the Antarctic. These will provide critical data for documenting long-term trends in ice thickness and improving climate models. Australia is also an active participant in the Antarctic Drifting Buoy Programme.

Vegetation and the biosphere



Studies of vegetation and the land surface play an important role in climate change research. Relevant biological research is proceeding at a large number of Australian universities, CSIRO and government agencies such as the Bureau of Resource Sciences and State Departments of Agriculture.

Australian researchers have been prominent in developing a more profound understanding of the direct effects of CO₂ on vegetation. A range of studies have been undertaken in glasshouses, in temperature-CO₂ gradient tunnels, and in the field.

Modelling of vegetation-climate interactions is also a significant aspect of Australia's research program. The modelling work has been supported by field programs such as OASIS (Observations at Several Interacting Scales), which examined exchanges of energy, water and trace gases between the atmosphere and land surface at scales ranging from that of a leaf to the regional.

Australia hosts the IGBP Global Change and Terrestrial Ecosystems (GCTE) core project office, and a number of GCTE research projects are undertaken here. These include studies into: the effects of enhanced carbon dioxide on the biosphere; global change impacts on pastures and rangelands, and on pests, diseases and weeds; and the biogeochemical, hydrological and ecological relationships between the land surface and the atmosphere in northern Australia.

The Australian Government has also supported a number of projects intended to improve the National Greenhouse Gas Inventory. Several of these have focused on aspects of vegetation, such as ecosystem dynamics hypothesised to be important in climate-biosphere feedbacks.

Australia participates in the Regional Interactions of Climate and Ecosystems (RICE) project of the Global Analysis, Interpretation and Modelling (GAIM) program, which is part of the IGBP. This work focuses on the impact of land use change on regional and global climates, and the impact of new dynamic vegetation models on GCM simulations.

Paleoclimate

Australian scientists are contributing to various components of the core IGBP program Past Global Changes (PAGES). These include: the meridional transect of the Paleoclimates of the Northern and Southern Hemisphere project, which extends through Australia; and analysis of coral cores to investigate climate variability over the past few thousand years.

Climate modelling

The National Greenhouse Research Program has contributed to accelerated development of climate models by the Bureau of Meteorology and CSIRO.

Australia's active program of climate model development has produced fully coupled ocean/atmosphere/sea-ice models for a range of studies, including global climate change research. Results from Australian climate models have been included in IPCC assessments.

Australian modelling groups have participated in the major international model intercomparison projects - including the Atmospheric Model Intercomparison Project (AMIP) and the Feedback Analysis of Global climate models for Intercomparison with Observations (FANGIO). In addition, Australian researchers coordinated the Project for the Intercomparison of Land-surface Parameterisation Schemes (PILPS).

The recent IPCC report drew attention to the development of regional climate models, sometimes 'nested' within global models to obtain higher resolution simulations over individual regions of interest. The Australian program has been pursuing this approach for a number of years, and several high resolution climate change simulations over Australia and elsewhere have been completed. High resolution models are also being used to study particular phenomena such as tropical cyclones, cut-off lows and monsoon systems.

INTERNATIONAL COOPERATION

Apart from New Zealand, Australia is the only Annex I country in the southern hemisphere. Australia's research activities on climate change are influenced by the opportunities presented by its geographic location.

Table 8.1 summarises a few key international science activities, with emphasis on Australia's contributions to the World Meteorological Organization's data collection and monitoring programs, the World Climate Research Programme and the International Geosphere–Biosphere Programme. The table illustrates the extensive nature of Australia's activities.

As well as contributing to these formally established international programs and projects, Australian scientists participate in a wide range of bilateral activities. For example, climate models developed in Australia have been made available to researchers in Argentina, Indonesia, Japan, New Zealand and South Africa. Sometimes, these modelling projects are intended to contribute to capacity-building. In such cases, Australian institutions such as the Bureau of Meteorology, CSIRO and universities have conducted training programs, either within Australia or in neighbouring countries.

Intergovernmental Panel on Climate Change

Australian scientists have played a substantial role in the work of the IPCC. A number have been lead authors, authors or contributors to the various reports produced by the IPCC, and have participated in the peer and country review process. Australia has also hosted formal workshops in support of the IPCC work program, and contributed funding to others hosted elsewhere.

Other international cooperation

Australia has provided support for regional initiatives such as the South Pacific Sea Level and Climate Monitoring Project, the ASEAN–Australia Maritime Science (Tides) Project and the Pacific Meteorological Services Project, as well as training and technical assistance on climate matters to neighbouring South Pacific countries. Technical advice and assistance is also provided to neighbouring countries to help improve the data management and climate monitoring capabilities of their national meteorological services.

CLIMATE IMPACT STUDIES

Australian scientists have been actively involved in a wide range of climate impact studies through CSIRO, universities and a small number of private companies. These studies have contributed to the World Climate Impact Assessment and Response Strategies Programme of the World Climate Programme (WCP) in a number of sectors. The climate scenarios used in Australian studies of the impacts of climate change and variability have been based on Australian GCMs run by CSIRO, the Bureau of Meteorology and Macquarie University.

Detail on the results of impacts and adaptation research are provided in Chapter 6 'Impacts, vulnerability and adaptation'.

Agriculture and fisheries

A range of studies have been undertaken on the impacts of climate change on agriculture. Assessments have been carried out of potential impacts on both crops and livestock through studies of projected availabilities of nutrients and water, temperature effects and changes in pest distribution. Studies have included:

- examination of such questions as the impact of climate change on forage and animal production, and the economic implications of this for farm viability; and



Table 8.1: A sample of Australia contributions to international science programs relevant to climate change

International Program/Project	Activity	Lead Institution
International Data Collection and Monitoring		
Global Climate Observing System (GCOS)	Joint GCOS and GOOS working group established	BOM
Global Ocean Observing System(GOOS)		
WMO Climate Change Detection Project	Data from the Climate Reference Stations	BOM
Global Atmosphere Watch	Background Air Pollution Monitoring Network station	BOM and CSIRO
World Climate Research Programme		
Global Energy and Water Cycle Experiment (GEWEX)	Participation in AMIP and FANGIO Participation in the Cloud System Study Working Group on Numerical Experimentation	BOM and CSIRO BOM BOM and CSIRO
Climate Variability and Predictability (CLIVAR)	Participation in CLIVAR science plan development Active involvement in all CLIVAR component programs	BOM, CSIRO and universities
Stratospheric Processes and their Role in Climate (SPARC)	Routine monitoring of Ozone Ozone modelling	BOM CRC SHM
Arctic Climate System Study (ACSYS)	Contributes to Antarctic Sea- ice Thickness Monitoring Programme Contributes to Antarctic Drifting Buoy Programme	AAD and Antarctic CRC
World Ocean Circulation Experiment (WOCE)	Ocean observations and modelling	CSIRO, BOM and Antarctic CRC
International Geosphere– Biosphere Programme		
Global Change in Terrestrial Ecosystems (GCTE)	Hosts core project office	CSIRO
GCTE joint with START	Major financial and scientific contribution to Biotrope South-East Asian Impacts Centre	AusAID, CSIRO
International Global Atmospheric Chemistry (IGAC)	Coordinated Aerosol Characterisation Experiment (ACE-1) Led South-East Asian DEBITS activity Coordinated halocarbon intercomparison	CSIRO
Past Global Changes (PAGES)	Contribution to most PAGES projects	Universities, AIMS, ANSTO and AAD
Joint Global Ocean Flux Study (JGOFS)	Participates in JGOFS planning, cruises and modelling	CSIRO, AIMS and AGSO
Global Analysis, Interpretation and Modelling (GAIM)	Participation through Regional Interactions of Climate and Ecosystems project	Macquarie University
Capacity building		
Global Change System for Analysis, Research and Training (START)	Support for analysis Observation and modelling projects in the Asia Pacific region	CSIRO, BOM and Universities

- the development of a generic approach to defining impacts on insect pests, plant pathogens, weeds, livestock parasites and vector-borne diseases.

Studies into the impact of climate change on a number of commercial fishing stocks have also been carried out.

Hydrology and water resources

Several studies have examined the impact of climate change on rainfall runoff and soil moisture for various catchments around Australia. Changes in the frequency and duration of snow cover under a number of climate change scenarios have also been examined.

Forests

A range of studies have been undertaken to investigate the impact of climate change on forest growth due to changes in carbon dioxide levels, temperature, nutrient levels and rainfall.

Natural ecosystems

Studies of the effects of climate change on aspects of natural ecosystems have included research on impacts on endangered and vulnerable vertebrate species, and paleoclimatic analysis of the response of woodlands to climate change and the implications for biodiversity.

Coasts

As most of Australia's population lives on the coastal margins, and these are the location of much of Australia's economic activity, potential impacts of climate change on coastal areas are particularly significant. A number of studies have assessed the impacts of climate change – through sea level rise, changes in storm frequency and intensity, and salt water intrusion into ground water supplies – on the economic, cultural and natural values of the coastal zone.

Human health

Research has been undertaken into the impact of climate change on the distribution of various diseases and pests, and into temperature- dependent mortality arising from extreme events.

Extreme weather

Studies of the impacts of climate change on various forms of severe weather have included assessments of changes to the strength and frequency of tropical cyclones, storm surges, urban flooding events, temperature and rainfall events and hail damage to crops.

CLIMATE RESPONSE STUDIES

A wide range of studies have been undertaken of the effects of various response options to climate variability and change.

Energy sector

Studies of responses in the energy sector have included research on reductions in coal-derived emissions through improved combustion technologies and their economic implications for the energy industry. Economic studies have been conducted at a national scale on the impacts of emission reductions through fuel substitution and improved efficiencies in the transport and energy sectors. Social aspects of changes in energy usage and efficiencies in the residential sector have also been studied. More details can be found in Chapter 4 'Policies and measures'.



Agriculture sector

A wide range of studies have investigated responses to climate change in the agriculture sector. Examples include work on: the sensitivity of greenhouse emissions to changes in stocking rate and fire management strategies; changes in methane production by ruminants through microbial and dietary management; and the potential for carbon sequestration in agricultural soils. Adaptive studies have included research on genetic modification of crop and pastures species, and improving the growth and water use efficiencies of crops at elevated carbon dioxide levels.

Forestry sector

Research on forest-related responses to climate change has included investigations into species suitable for agro-forestry applications and the use of climate variables to map environments suitable for various tree species.

Human health

Potential impacts of climate change on human health have been identified, and a number of research institutions are undertaking research into primary prevention measures and adaptive strategies.

Urban environment

Issues addressed in studies of climate change adaptation options in the urban environment include: the design of storm water systems; modification of urban transport systems; energy efficiency standards for buildings; and planning decisions relating to sea level rise.

Economic research

The Australian Bureau of Agricultural and Resource Economics (ABARE) is conducting a major program of research to identify optimal international policies for responding to the climate change issue and appropriate relationships between international and national policy. The program also includes the development of projections of future greenhouse gas emissions under different scenarios.

ABARE has developed and applied a computable general equilibrium model of the world economy, MEGABARE, to assist policy makers here and in other countries to better understand the equity, effectiveness and efficiency consequences of different climate change policies.

The next generation MEGABARE model, GIGABARE, is now being constructed. GIGABARE will provide a greater level of country and commodity disaggregation. It will also incorporate a number of important new capabilities, for example to integrate climate change impacts with assessments of the costs of policy, to draw on the engineering detail of 'bottom-up' models of energy systems, and to incorporate forest sinks.

ABARE is also continuing development and application of the MARKAL-MENSA model to better determine least-cost response options in Australia at energy sector and sub-sector levels. Its researchers have collaborated with economic research organisations in several Asian countries to help them undertake MARKAL-based analyses of their own energy systems to identify least-cost response options. This work has taken place as part of an Asian Development Bank/Global Environment Facility program.

Education, training and public awareness

INTRODUCTION

Australia's national greenhouse response includes community information and education programs with the objectives of increasing public awareness of climate change, developing individual and organisational commitment to emission reduction and promoting behavioural change.

Activities concerned with public awareness, education and training on greenhouse and related issues are undertaken by the three levels of government, by industry and by non-government agencies. Agencies have both internal and external objectives - relating to increasing the knowledge of their own staff and stakeholders and changing their own activities as well as educating external stakeholders and encouraging behavioural change within the broader community. The different levels of government have taken responsibility for the parts of the education and information response which are consistent with their governing responsibilities.

Considerable activity has occurred in recent years. Many projects previously reported are continuing, and new activities have been developed to promote increased community awareness about climate change and knowledge of how individuals and organisations can contribute effectively to its management. Many activities have produced tangible results and set directions for future action. The types of projects undertaken include:

- printed and electronic publications such as information pamphlets, books, flyers, posters and web sites which detail how individuals, business and industry can reduce waste and minimise the emission of greenhouse gases;
- training programs for those involved in developing environmentally friendly communities;
- production of curricula for schools and universities on the reduction of emissions and protection of sinks;
- initiatives designed to have a direct impact on the emission of greenhouse gases, such as monitoring programs and provision of recycling facilities;
- award schemes which recognise and reward organisations developing best practice models in the reduction of greenhouse gas emissions;
- local area and organisational response strategies and input to policies affecting climate; and
- the development and active marketing of energy efficient housing, transport and land development proposals.

The broad nature of activities undertaken by different sectors is presented below, and particularly innovative developments are highlighted. The information provided is a series of examples rather than a comprehensive listing of the work being undertaken across Australia in raising public awareness and educating broad sectors of the community in greenhouse issues. All of the programs assist individuals and organisations to take concrete steps in changing their behaviours to ensure reductions of greenhouse gas emissions and to manage the effects of climate change.

COMMONWEALTH GOVERNMENT INITIATIVES

As outlined in the Introduction, the Government is currently undertaking a major review of the 1992 National Greenhouse Strategy, including its modules on community information and education. Outcomes from this review will build on the framework established by the 1992 Strategy. The Strategy places a strong emphasis on the need to systematically address the information needs of the Australian community, and a range of measures is being implemented to achieve this objective.

A number of Commonwealth departments undertake general community education. Several have released publications informing people about ways in which they can minimise greenhouse gas emissions. For example, the Department of Primary Industries and Energy has produced targeted publications on fuel consumption, renewable energy and 'energy smart' homes. Environment Australia recently produced a booklet setting out concrete steps individuals can take in their daily lives to reduce greenhouse gas emissions (see box '*Global Warming - Cool it!*').

Global Warming - Cool it!

Produced by Environment Australia, this practical booklet is a home guide to reducing energy costs and residential greenhouse gases. It explains the global warming problem in simple, everyday terms, and identifies ways in which householders can be part of the solution in the areas of transport, water heating, home heating and cooling, cooking, lighting, clothes washing and drying, and in the garden.

This innovative booklet can be viewed on the World Wide Web at:

www.environment.gov.au/net/coolit.html

A number of programs that contribute to information, education and training goals relating to a range of natural resource management issues also contribute to greenhouse awareness. For example, the National Landcare Program provides funding assistance to encourage rural community groups to develop a self-help attitude and capacity in planning, promoting and using sustainable land, water and vegetation management practices. Landcare encourages integrated natural resource management through the development and use of better management practices so that rural industries, regions and communities will have a sustainable future. This includes significant action that will have greenhouse-positive outcomes. Similar programs announced under the Natural Heritage Trust - for example, Bushcare, Rivercare and Farm Forestry - will have similar outcomes.

International activities that feature in Australia's information and education response include the provision of coal technology education for other countries. Training courses aimed at improving the environmental and greenhouse performance of coal use in other countries are run both in Australia and abroad. These courses address the broad range of technical and managerial skills needed to use coal cleanly and efficiently. They meet an urgent need to ensure the transfer of such skills to developing countries where coal use is expanding rapidly.

Australia also makes a substantial contribution in the international arena through bilateral technology transfer, environmental management and regional response development programs with other Governments in the Asia-Pacific region.

The Greencorp Program administered by the Department of Employment, Education, Training and Youth Affairs promotes opportunities for long-term unemployed young people to learn and practice skills in environmental management, and represents part of the Commonwealth Government's commitment to greenhouse education.

An Environmental Management Program for small business is delivered by the Department of Industry, Science and Tourism, through AusIndustry. This scheme provides training, and includes a subsidy for businesses to assist them in engaging a specialist consultant to aid in the development and implementation of an environmental management plan.

Many departments have also instigated internal activities to reduce greenhouse gas emissions and contribute to the future management of climate change. Strategies include the production and distribution of publications and the training of staff regarding recycling and efficient energy use in areas ranging from paper use to building energy management. The Department of Defence, for example, offers Energy Management Training Programs to personnel and provides an energy management checklist to assist people in the efficient use of energy sources. All departments provide recycling facilities, and many ensure that purchasing staff are aware of energy efficiency guidelines and identify equipment in accordance with these.

Greenhouse Challenge Program

The Greenhouse Challenge Program, established in 1995, is a successful program of cooperative agreements between industry and government. Participating companies undertake action to reduce or abate their greenhouse gas emissions through energy efficiency and other measures. Promotion of the Greenhouse Challenge is achieved through print, television and radio media, trade journals and a program of workshops with business.

The program, described in Chapter 4, 'Policies and Measures', includes activities which involve the dissemination of information, education and training. It identifies 'cultural change' within business as a major goal, and is currently developing tools which will allow participants to measure this workplace change. Through their participation in the Greenhouse Challenge, large corporations such as ICI Australia and Westpac Bank have undertaken staff training on greenhouse in an attempt to encourage workers to reduce emissions both in the workplace and at home.

Companies that have identified significant actions they can take to educate the broader community on greenhouse issues range from McDonald's to the Latrobe Valley Power Generators and Newcastle City Council.

STATE AND TERRITORY GOVERNMENT INITIATIVES

With the Commonwealth Government taking responsibility for national publications, whole community and international activities, State and Territory Governments have focused on their own communities and areas of responsibility.

In Victoria, release of the booklet *Energy Management in Corner Shops* is expected to yield savings in excess of \$1.3 million in energy costs and 13 kilotonnes of CO₂ over the next ten years. This booklet was distributed to 2400 agencies. Similar educational projects have been conducted for larger businesses through the Energy Smart Companies program.

The Green Power Accreditation Program could be one of the largest green power schemes in the world; through it, eight power retailers in New South Wales offer products which guarantee investment in renewable energy sources. Raising consumer awareness of these services is vital to the success of the program, and it is supported by extensive State-wide advertising campaigns.

State and Territory Governments have taken a leading role in the development of publications for schools and community members on energy efficiency, the science of climate change and recycling. For example, Queensland has produced resources for schools that include mapping activities on air quality, ten ways to be a 'green student', and promotional material on public transport, bicycle use and walking. In the Northern Territory, teachers receive professional development training and regular updates on greenhouse issues to ensure the provision of accurate information to students. The South Australian Department of the Environment produces a biannual magazine on environmental issues which is distributed to schools, government offices and private companies. Education kits for use in schools, with titles including *The Air We Breathe* and *Angles on Energy*, have been produced in many States.



In New South Wales, the Hawkesbury Nepean Catchment Management Trust's Greenhouse Parks Program provides greenhouse educational materials and assists schools in conducting energy audits which identify potential reductions in greenhouse gas emissions. Indigenous seedlings are provided as rewards, and planted at sites, known as Greenhouse Parks, provided by Local Governments.

State Governments are active in determining greenhouse targets within State Transport Strategies. Providing appropriate information to communities is a component of these strategies, which address: increasing the use of non-motorised modes of transport; minimising the use of private vehicles; better integrating services; expansion of bicycle networks; and the provision of high quality pedestrian environments and facilities.

Energy Smart Companies is a corporate commitment program in Victoria which facilitates improved energy management practices by companies. It offers information, training, publication of case studies, media campaigns and industry awards to its 250 members. Conservative estimates indicate this program will yield savings in excess of \$30 million in energy costs and about 300 kilotonnes of CO₂ over the next ten years.

State electricity suppliers print information on accounts which allows consumers to monitor usage and identify successful emission reduction and energy saving strategies.

Many State and Territory Government agencies offer Award Schemes aimed at rewarding best practice in energy efficiency and emission reduction activities and practices across a range of industries including manufacturing, transport, architecture and building. These have an important role in educating industry and the community about greenhouse issues and best practice.

LOCAL GOVERNMENT INITIATIVES

Local councils are active in educating residents and encouraging community greenhouse response action. Support for this activity has been provided by Environment Australia through its funding of the Environment Resource Officer Network. This program places an Environment Resource Officer in each State Local Government Association to provide information and advice to local councils on a range of environmental issues.

The Newcastle City Council in NSW has been entrepreneurial in its approach, employing an Energy Officer who is effectively funded by the money saved by the council through the implementation of energy efficiency programs. The Energy Officer works with local industry as well as acting as an information source for the broader community.

Many Local Government organisations, including those in Victoria, South Australia and NSW, have been involved in the development of 'urban villages' demonstrating that urban design and environmental principles can be applied to existing and new residential areas to reduce greenhouse gas emissions and promote sustainable urban lifestyles. For example, the Energy Park established by Brunswick Council, Victoria, displays renewable energy technologies such as wind and solar power, and explanatory tours are conducted. The Park also contains a low energy house offering a practical demonstration of cost-effective methods for reducing energy consumption - including insulation and draught sealing techniques, renewable energy technologies, elements of passive solar design, and innovative gardening and recycling processes.

Like many others, the Armidale City Council, NSW, recognises the role it plays in the assessment of land subdivisions and developments, and has developed a comprehensive strategy for residential energy efficiency. This is based on a three-part action plan involving: financial, educational and regulatory components covering new subdivisions and housing design; interest free loans for insulation; and construction of energy efficient display homes.

Councils across the nation are actively involved in waste management programs ranging from large-

scale recycling programs to simple strategies such as the sale of compost bins at low cost to residents. Waverley Council, NSW, is one that has amended its Development Control Plan for Residential Flat Buildings to ensure that new buildings provide allocated space for the collection of recyclable materials. Educating householders about the importance of their participation has been a vital contributor to the success of these programs.

Local Government is active in producing publications aimed at increasing public awareness of environmental and greenhouse issues. In Tasmania, for example, the Local Government Association produces *Enviro Update* monthly, and has made inputs to a variety of State and local policies related to, or having an impact on, climate change. Leichhardt Council in NSW has produced the 'Solarpak - Energy Efficient Housing Program', while the Armidale City Council has provided a promotional pack including the booklet *Energy Efficient Housing*. These packages include information on space heating, solar passive design/orientation, insulation and other issues.

Many local councils have developed and actively marketed to the general public, using an environmental theme, programs selling alternative and renewable power sources. Moreland City Council, Victoria, for example, has instituted an Ecopower system whereby consumers can purchase units of energy from renewable sources such as the Energy Park and wind farms.

Cities for Climate Protection – Australian campaign

To assist Local Government action, the Commonwealth Government has funded Australia's involvement in the international program Cities for Climate Protection Campaign. This program aims, by providing information, tools and a formal structure, to help Local Governments meet their emission reduction goals.

The Australian campaign will use two tools - a software program for measuring greenhouse gas emission reductions from specific activities, and a workbook that will guide city staff through every step of the campaign, from how to conduct an emissions survey to developing the local action plan. The International Council for Local Environmental Initiatives (ICLEI), Environs Australia and the Australian Local Government Association will work in partnership to deliver the program.

COMMONWEALTH SCIENTIFIC AND INDUSTRY RESEARCH ORGANISATION (CSIRO) INITIATIVES

As well as undertaking research, CSIRO plays an important role in providing formal education and training on climate change to scientists, industry, government and educational institutions. It also uses a range of strategies to disseminate current information to increase public awareness and promote behavioural change.

CSIRO scientists are actively involved in providing tertiary training relating to the science of climate change - for example, delivering lectures and supervising postgraduate students. Others have published numerous works focusing on climate change and related matters. Educational materials produced by CSIRO are used extensively in schools and tertiary institutions, and tens of thousands of students are accessed through its magazines *The Helix* and *Ecos* and classroom presentations undertaken by CSIRO Education Programs staff.

CSIRO conducts regular training courses in various aspects of climate change science for delegates from overseas countries. For example, training for Asian scientists on climate modelling and greenhouse gas measurements is provided through the International Geosphere-Biosphere Programme (IGBP). In addition to such programs, CSIRO organises climate change briefings, meetings, workshops and conferences which are attended by scientists, government and industry delegates, community representatives and members of the public.



To explain the latest research findings on climate change, staff write articles for newspapers, magazines and journals, provide regular briefings to journalists, appear regularly on television and radio, and maintain a comprehensive World Wide Web site. Open Days also form an important part of CSIRO's public awareness raising activities. For example, thousands of people attended the latest annual Division of Atmospheric Research Open Day, and survey results showed that their visits had provided them with further environmental knowledge and gained increased public support for environmental research.

NON-GOVERNMENT ORGANISATIONS

Australia's non-government sector comprises many organisations spanning a wide range of functions and objectives. Those relevant to climate change include conservation organisations, peak bodies for business, power/energy providers, bodies representing sectors that will be affected by climate change, and organisations established to respond to changing energy needs. All contribute to raising public awareness about greenhouse through research, campaigns, lobbying, education and training.

The peak bodies representing energy producers and providers have responded diversely to the impact of climate change. For example, the Australian Gas Association is promoting gas as the bridge between the current use of non-renewable fossil fuels and future use of renewable energy sources. The Electricity Supply Association of Australia has created a Directorate of the Environment which drives its environmental activity. It has launched a major internal education campaign aimed at encouraging members to join the Greenhouse Challenge Program. Similarly, the Australian Coal Association (ACA) has conducted workshops in each State to encourage members to join the Greenhouse Challenge. In 1994 it released its own strategy, 'ACA Undertaking on Greenhouse'.

The National Farmers' Federation is one of many peak bodies that are undertaking research projects and establishing internal policy on environmental issues. Such activities require considerable awareness-raising and consultation among their membership.

The Australian Conservation Foundation is active in lobbying governments and industry on a range of environmental issues. It produces information for individuals, schools and other organisations, and conducts a range of training programs. In conjunction with the Australian Council of Trade Unions (ACTU) Green Jobs Unit, the Foundation supported more than 150 graduate placements to oversee energy and waste management in small businesses. This program has substantially increased awareness of greenhouse and energy management issues in the business sector, and has resulted in tangible behavioural changes.

One company, a major energy management trainer in the Asia-Pacific region, has developed a package which allows firms to evaluate energy management activities within a total quality management framework. This shift is important as it highlights the mainstreaming of energy issues into routine business and household management activities.

The Sustainable Energy Industries Council of Australia (SEICA) adopts a high level lobbying and advocacy role, and publishes a vast amount of material for government, media and industry forums.

The World Wide Web

One necessary development over recent years has been the provision of electronic information across the World Wide Web. Many organisations have web sites maintaining current information on greenhouse and other environmental issues. This medium is critical to public awareness. In the future the creative and effective use of electronic information will guarantee the broadest possible reach and considerably boost the speed of information dissemination. Some useful climate change sites are:

Environment Australia

www.environment.gov.au/air/air.html

Department of Foreign Affairs and Trade

www.dfat.gov.au/ild/climate/cctf_home.html

Department of Primary Industries and Energy

www.dpie.gov.au

Sustainable Energy Industries Council of Australia (SEICA)

www.spirit.com.au/~gregoryw/seica.html

Australian Local Government Association

www.alga.com.au

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

www.csiro.au

