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Report on the in-depth review of the second national communication of Australia

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I. INTRODUCTION AND NATIONAL CIRCUMSTANCES

1. Australia ratified the UNFCCC on 30 December 1992. Its first national communication (NC1) was submitted to the secretariat on 19 September 1994 and the second national communication (NC2) on 15 November 1997. The in-depth review of the NC2 was conducted between September 1998 and April 1999 and included a visit to Canberra from 7 to 11 September 1998. The team comprised Mr. Dadi Zhou (China), Mr. Samuel Adejuwon (Nigeria), Mr. Milos Tichy (Czech Republic), Mr. Matthew Everett (New Zealand), Ms. Amrita Achanta (UNFCCC secretariat) and Ms. June Budhoooram (UNFCCC secretariat, coordinator). The in-depth review was coordinated by the Australian Greenhouse Office (AGO) and involved discussions with key stakeholders in government, the business community and non-governmental organizations.
2. Two main institutional features form the framework of climate change policy in Australia: as a federation of States, the Commonwealth Government has relatively limited constitutional powers; on the other hand, State governments have extensive jurisdiction for land management, natural resources (including energy), urban planning and transport. This means that there is a regular need to coordinate Commonwealth and state climate policies. Additionally Australia also has a distinctive profile of greenhouse gas (GHG) emissions compared with other Annex I countries reflecting its reliance on fossil fuels, strong population growth, and economic emphasis upon the utilization of natural resources. As a result, emissions and sequestration from the agriculture, land management and forestry sectors form a substantial proportion of the emissions inventory.
3. Australia first established a national policy position on climate change in 1989. This led to a national response to climate change, with the Commonwealth, State and Territory governments, and the Australian Local Government Association, endorsing jointly a National Greenhouse Response Strategy (NGRS) in 1992. As reported in the NC1, the Commonwealth Government adopted the so-called "Toronto target" of stabilizing Australia's GHG emissions at 1988 levels by the year 2000, with a further 20 per cent reduction by 2005. The team felt that in hindsight this objective proved to be too ambitious.
4. The NGRS outlined specific strategies for limiting GHGs in such areas as energy supply, household, industrial and commercial energy use, transport, agriculture, and the natural environment. Other key aspects were the promotion of research, education and community involvement, and the introduction of the Greenhouse Challenge Program (GCP), a cooperative voluntary initiative between industry and Government to mitigate GHG emissions through energy efficiency and other measures.
5. The NGRS was thoroughly reviewed in late 1996 by the Commonwealth and State governments, in consultation with industry and the community. Concurrently, the Commonwealth Government was closely examining how to meet its international commitments on GHG abatement. All this eventually led to what is known as the "Prime Minister's package", which was introduced on 27 November 1997 (just prior to the publication of the NC2), and the

formulation by Commonwealth, State and Territory Governments of the National Greenhouse Strategy (NGS), which was approved by Parliament in November 1998. Specific implementation plans are being developed by each of the Commonwealth, States and Territories for the measures in the NGS.

6. With a budget of \$A 180 million, the Prime Minister's five-year package has established a long-term climate change vision for Australia, embodied in the NGS, with some measures going beyond a "no-regrets" framework. Australia's net emissions growth (reflecting emissions from all sectors but not including land clearing emissions) is expected to fall from 43 per cent above 1990 levels - the rate known as business-as-usual - to 18 per cent by the year 2010. The package, among other things, established the Australian Greenhouse Office (AGO), set a mandatory target for electricity retailers to derive an additional 2 per cent of their electricity from renewable sources by 2010, and set aside \$A 60 million to commercialize renewable energy technology. Some of the more specific NGS programmes under implementation are aimed at accelerating market reform in electricity generation and energy efficiency standards; improving motor vehicle fuel efficiency by 15 per cent; adopting building codes and standards; fostering plantation forestry and native revegetation; strengthening voluntary industry action under the Greenhouse Challenge Program; and increasing support to the International Cities for Climate Protection™ campaign.

7. Australia's projected net emissions growth will be further reduced below the projected level of 118 per cent in 2010 through a combination of implementation measures in the NGS, reduction in land clearing activities and use of the three Kyoto mechanisms, including international emissions trading.

8. In a major new development the Commonwealth Parliament has recently passed legislation for a new tax system, including a major package of new greenhouse programs in renewable energy and conversion of vehicles to compressed natural gas. The Commonwealth package also includes an \$A 100 million a year Greenhouse Gas Abatement Program, for which actions (worth \$A 400 over the four years of the program) are to be developed, in consultation with stakeholders. The Program will focus on maximum abatement and sequestration opportunities. It will become operational in July 2000.

9. A number of mechanisms support the Prime Minister's 1997 package and the NGS. These include stakeholder advisory fora and measure-specific consultations which bring in key players from diverse groups including environmental groups and industry associations. Government has also established an Expert Group to investigate a possible domestic emissions trading scheme, and a Commonwealth, State and Territory body to oversight implementation planning for the NGS. As of January 1999, detailed implementation plans for the NGS were under development by all governments concerned, in consultation with all relevant stakeholders.

10. The AGO is the lead Commonwealth agency on greenhouse matters and is responsible for leading domestic climate change policy and implementing the national greenhouse response programmes at a Commonwealth level. Experts indicated to the Review Team that the AGO is

the world's first national office dedicated to greenhouse response. The AGO has the critical role of providing linkages between key stakeholders in government, industry and the community through a variety of stakeholder consultation mechanisms. Consultation with stakeholders on greenhouse issues and the facilitation of stakeholder input into greenhouse related programme development and implementation is enabled through mechanisms incorporated in most greenhouse-related programmes.

11. The NC2 stated that Australia's GHG emissions would be 43 per cent above their 1990 level in 2010, without rigorous abatement measures. Even with measures implemented to date, Australia will not be able to reduce GHG emissions to their 1990 levels in 2000. As a result of the Prime Minister's package projected emissions growth is expected to be lowered to 18 per cent, a figure which does not include the measures included in the NGS. On 29 April 1998, Australia signed the Kyoto Protocol. If ratified, emissions growth in the commitment period 2008-2012 must be limited to only 8 per cent compared to 1990.

12. The Australian experts informed the review team that climate change is being given high priority and that a number of new initiatives have been proposed under the NGS which target GHG emissions reduction in a more systematic manner. However at present, it is difficult to accurately assess Australia's progress toward meeting its GHG target of reducing GHG emissions to 108 per cent of 1990 levels by the year 2010, since many of the Government's policies and measures are still in the planning or early implementation phase and baseline information on carbon sink status related to land use change is still being refined. The team noted that the NC2 refers to many measures that the Government is considering and which, if adopted, could significantly contribute to GHG abatement.

II. INVENTORIES OF ANTHROPOGENIC EMISSIONS AND REMOVALS

13. The review of Australia's GHG inventory was based on information presented in the NC2 and in the workbooks prepared for each category of the inventory. Although the NC2 presents only summary tables for the 1995 inventory and reports aggregate emissions and sinks for the period 1990-1995, this minor shortcoming notwithstanding, the NC2 together with the workbooks comprise an extremely well-elaborated set of documentation, including a complete set of inventory data covering a comprehensive list of sources of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and the new gases, carbon tetrafluoride (CF₄) and hexafluoroethane (C₂F₆), chlorofluorocarbon (CFC) substitutes not controlled by the Montreal Protocol.

14. With a few exceptions, the inventory was prepared applying the 1995 Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC). While the NC2 did not include data on hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF₆), this information was subsequently provided to the review team. Although emissions of sulphur dioxide and terrestrial ozone precursors (non-methane volatile organic compounds, nitrogen oxides, carbon monoxide) went unreported in the NC2, 1995 estimates of these gases are contained in a separate report. The 1996 GHG inventory was also presented to the team, in which the 1996 Revised IPCC Guidelines are applied, and which reported emissions of HFCs,

SF₆ and revised inventories for 1990-1995. The inventory team explained that because of relatively large uncertainties presently associated with emissions emanating from land clearing, these were reported in the NC2 inventory and in the 1996 inventory separate from the totals of emissions from the other sectors. In compiling the inventories, the latest revised values for global warming potentials (GWP), as adopted by the IPCC, were applied. The Australian financial year, which runs from July to June, is the reporting year for GHG emissions and no adjustments were made for climate or other factors.

15. The review team noted the efficient organization in place for preparing the inventory. It is compiled by the AGO and is managed through the National Greenhouse Gas Inventory Committee (NGGIC), a body comprising representatives of the Commonwealth, State and Territory governments. This Committee runs task forces composed of experts from State organizations, industry, non-governmental organizations, and academia. Its main function is to approve both methodology and inventory results on a consensus basis. Committee findings are publicly discussed and published, a process which increases overall confidence in the inventory.

16. The team agreed that there was a vast improvement between the NC1 and the NC2. The GHG inventory published in the NC1 contained data for 1990 only, whereas the NC2 covers 1990-1995. Overall, the NC2 is more extensively documented and appears to be more robust from a methodological standpoint. Most of the inventory is now calculated from activity data drawn from official statistics or directly from industries. In most cases, country-specific emission factors for the Australian environment are applied. The revision of National Greenhouse Gas Inventory required to produce the Second National Communication has involved investment of over \$A 5 million so far, with continuing expenditure budgeted for the future.

17. The NC2 1990 inventory data on land clearing emissions were revised downward by 15 per cent as a direct result of having more accurate primary data on land clearing. Since the publication of the NC2 in 1997, considerable effort has gone into improving the accuracy of estimating GHG sources and removals in the land-use change and forestry (LUCF) sector. A preliminary model was introduced which applied more detail on regrowth following vegetation clearing, resulting in a downward revision of these emissions for the years 1990-1995. During the review, the national experts emphasized the complex and difficult nature of estimating emissions from land clearing. The methodology used in the 1990-1996 inventory adopts the IPCC default values for soil carbon change where forests are replaced with crops and pasture. Of technical interest is the fact that Australia adopts an exponential rate of change instead of a simple linear pattern as recommended by the IPCC. Another advance upon the IPCC default methodology is in the calculation of sinks due to crop growth following clearing for agriculture.

18. The revised CO₂ estimates for the LUCF sector also incorporate remotely-sensed 1991 to 1995 data for some States, and this has significantly increased confidence in the data. Rates of land clearing for 1991 to 1995 from the Agricultural Land Cover Change Project, coordinated by the Bureau of Rural Sciences (BRS), will be included in the 1997 inventory. The basis for

deriving estimates of CO₂ flux in the LUCF sector also improved markedly between the NC1 and the NC2, and thereafter.

19. The team learned that emissions from land clearing are on the decline as this activity is decreasing. Experts pointed out that there remains difficulty in estimating GHG sources and sinks in several areas, notably below-ground emissions and the nature and extent of vegetation cover. More specifically, some aspects of the inventory - such as land clearing rates; biomass removed by type; volume and mass of vegetation cleared; regrowth of vegetation in cleared areas; and the level and loss of carbon through soil disturbance - require more reliable data.

20. Future changes are expected to incorporate the results of the National Carbon Accounting System, a five-year project initiated in November 1997 to specifically address uncertainties in emission and sinks estimates for the LUCF and agriculture sectors. This initiative has wide participation from land management and research agencies in government as well as other stakeholders. Results from the programme are expected to progressively decrease uncertainties associated with these sectors. Other notable changes in the NC2 data and methodology include:

- Revised data on fugitive emissions from crude oil and natural gas production;
- Amended methodology for non-CO₂ emissions from aircraft which are included in transport emissions, as required in the revised 1996 IPCC Guidelines;
- Incremental improvements in data on area of land cleared and estimates of above-ground biomass in estimates of emissions from forest and grassland conversion (land clearing);
- Improved estimates of the lifetime of product pools in calculating decay of wood;
- Revised methodology and inclusion of N₂O emissions from agricultural soils and from livestock in the agriculture sector.

21. The NC2 inventory data were ranked according to high, medium and low uncertainties, as recommended by the IPCC Guidelines. These rankings are largely conceptual, based on the professional judgement of inventory experts, and have not been subjected to rigorous quantitative analysis. Confidence levels for CO₂ emission estimates were highest for combustion, followed by industry. Uncertainty was gauged at less than 5 per cent and 10 per cent, respectively. Confidence levels were lowest in agriculture, waste, and LUCF where uncertainty was 20 to 80 per cent, greater than 50 per cent, and greater than 80 per cent, respectively. This situation is improving, as studies carried out in 1996 have lowered overall uncertainty in the LUCF sector to 66 per cent. As pointed out to the team, varying degrees of uncertainty are a result of inadequate raw data; lack of understanding of the fundamental processes that result in GHG emissions and creation of sinks; and averaging to capture conditions across a range of very different environments in Australia.

22. The updated 1990-1996 inventory indicates that total net emissions of GHGs (excluding land clearing) increased by 9 per cent over the period. The energy sector was the biggest contributor, accounting for just under 80 per cent of national net emissions (1996), increasing by 12 per cent from 297,000 Gg to 332,000 Gg. Stationary energy sources had the highest total share of emissions at 55 per cent, followed by agriculture with 20 per cent. Transport made up

17 per cent of the total. Industrial processes and waste were relatively minor contributors to overall emissions. Conversely, forestry and others (pasture improvement) constituted a sink of 23,000 Gg in 1996, equivalent to about 5 per cent of total net emissions. On a gas-by-gas basis, emissions of CO₂ predominated in 1996, with 68 per cent in CO₂ equivalent terms. CH₄ features more strongly than in most of the other Annex I countries with 26 per cent, followed by N₂O at 5.7 per cent. The contribution of "new gases" is negligible (0.3 per cent). Sectoral distribution of GHGs was rather stable in 1990-1996, except for transport where emissions were rising.

A. Carbon dioxide

23. Total anthropogenic emissions of CO₂ were estimated at 308,413 Gg in 1996, an increase of 12 per cent from 1990 (see table 1). By sector, the bulk of CO₂ emissions came from energy transformation at 52.9 per cent, while transport 21.8 per cent, industry 15.9 per cent, commercial and institutional sectors 4.5 per cent, and industrial processes 2.3 per cent. The largest contributors were electricity generation, which is mainly coal-based, and road transport. Other energy sources such as fuel use in the residential sector, petroleum products use by equipment in agriculture, forestry and fishing, and fugitive fuel emissions contributed to a lesser extent.

24. CO₂ emissions from electricity generation, fuel combustion elsewhere and fugitive emissions increased by 15 per cent from 1990 to 1996. Following the IPCC Guidelines, international aviation and maritime bunker fuels were reported separately in the inventory and experienced an increase of 41 per cent between 1990 and 1996, with absolute values increasing from 6,401 Gg to 9,031 Gg.

Table 1. Carbon dioxide emissions and removals by sectors, 1990-1996 (Gg)

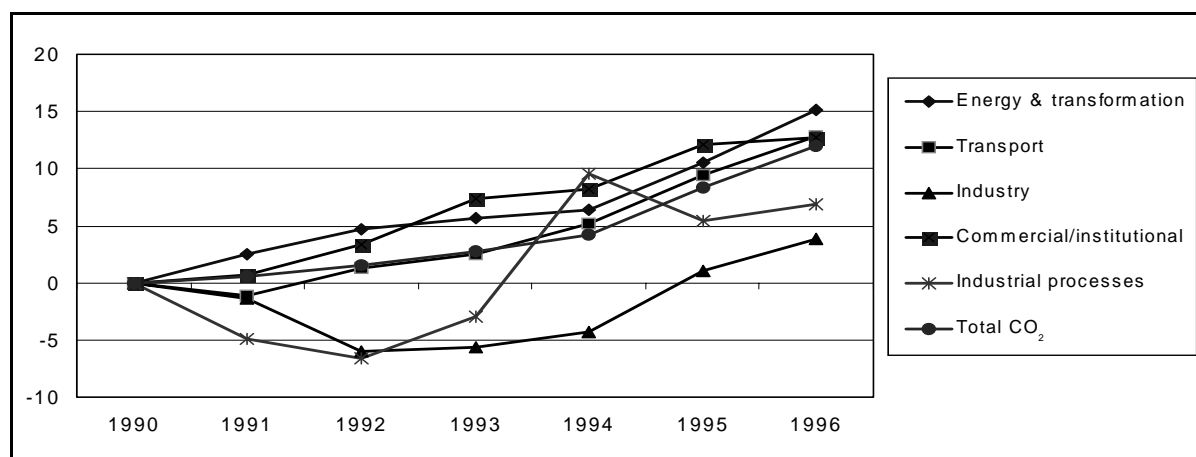
	1990	1991	1992	1993	1994	1995	1996
Energy & transformation	141 807	145 297	148 513	149 791	150 851	156 807	163 335
Transport	59 596	58 944	60 397	61 120	62 689	65 185	67 240
Industry	47 363	46 685	44 524	44 725	45 342	47 841	49 190
Commercial/institutional	12 178	12 258	12 592	13 070	13 181	13 646	13 727
Industrial processes	6 655	6 330	6 212	6 459	7 293	7 018	7 110
Other	8745	7495	7290	7751	7548	8804	7811
Total	275 344	277 009	279 528	282 916	286 904	298 301	308 413
LUCF (*)	58 872	50 752	46 980	44 673	38 160	37 144	36 262
Emissions	154 813	146 488	142 565	140 514	133 394	132 055	130 949
Removals	-95 941	-95 736	-95 585	-95 841	-95 234	-94 911	-94 687

(*) For the sake of comparison, the LUCF category has been segregated into its emissions and removals.

25. As seen in figure 1, CO₂ emissions since 1990 have increased across all sectors. The largest percentage increases are attributed to energy transformation (15.2 per cent), transport (12.8 per cent), and commercial/institutional (12.7 per cent). Similarly, net sinks in LUCF decreased by 1.3 per cent between 1990 and 1996, effectively increasing emissions, due to increased timber harvesting across Australia.

26. For the LUCF sector net CO₂ emissions decreased by 15 per cent between 1990 and 1996, declining from 154,813 Gg in 1990 to 130,949 Gg in 1996, with land clearing accounting for a major part of this. Removals by sinks decreased only marginally by 1 per cent during the same period.

Figure 1. Carbon dioxide emissions, percentage change from 1990, by sector



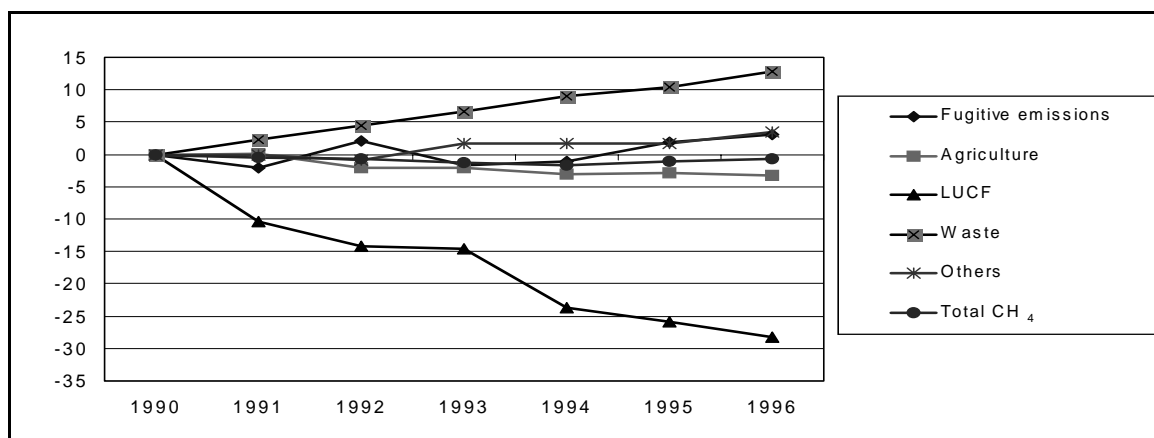
B. Methane

27. Total CH₄ emissions amounted to 5,308 Gg in 1996, a 1 per cent decrease from 1990 (see table 2). This reduction was due to a drought-related reduction in the livestock population during most of that period and also lowered crop production. Nevertheless, the agriculture sector remains the most significant contributor of CH₄ emissions, accounting for 58 per cent in 1996. Within the sector, livestock was the main source of CH₄, followed by rice cultivation and, to a lesser extent, savanna burning to improve grass production and field burning of crop residues.

Table 2. Methane emissions by sector, 1990-1996 (Gg)

	1990	1991	1992	1993	1994	1995	1996
Agriculture	3 200	3 206	3 136	3 131	3 104	3 106	3 096
Fugitive emissions	1 108	1 086	1 132	1 089	1 097	1 130	1 143
Waste	704	720	736	751	767	778	794
LUCF	220	197	189	188	168	163	158
Other	113	113	112	115	115	115	117
Total	5 345	5 322	5 305	5 274	5 251	5 292	5 308

Figure 2. Methane emissions, percentage change from 1990, by sector



28. Fugitive fuel emissions accounted for 22 per cent of total CH₄ emissions, with more than 78 per cent originating from coal mining and the rest from leakage in the gas production and distribution network. Waste accounted for 15 per cent of CH₄ emissions, almost all (92 per cent) coming from landfills, increasing since 1990 from 704 Gg to 794 Gg. The LUCF sector added another 3 per cent and other sources 2 per cent, the latter primarily from incomplete combustion of fossil fuels and biofuels.

C. Nitrous oxide

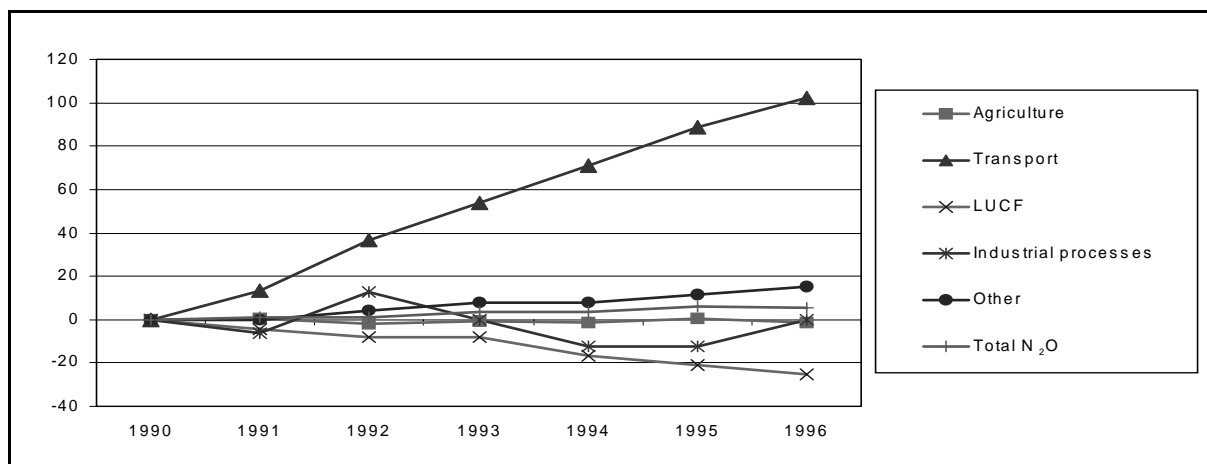
29. The N₂O inventory indicates that 1996 emissions amounted to 78.9 Gg, about 5.5 per cent greater than the 1990 level of 74.8 Gg. As shown in table 3, agriculture accounted for about 78 per cent of the total, largely from the application of fertilizers and from animal waste. Emissions from the combustion of transport fuels accounted for almost 13 per cent. Due to the rapid rise in the number of vehicles with catalytic converters, these emissions have doubled since 1990, increasing by 5.3 Gg in six years, to reach 6.7 per cent of the total in 1996.

30. N₂O emissions in the LUCF sector are largely a product of savanna burning and field burning of agricultural residues, a practice representing 2 per cent of emissions but which has been systematically on the decline since 1990. A relatively low level of N₂O emissions emanate from processes in the chemical industry.

Table 3. Nitrous oxide emissions by sector, 1990-1996 (Gg)

	1990	1991	1992	1993	1994	1995	1996
Agriculture	63.0	63.3	61.8	62.7	62.2	63.4	62
Transport	5.2	5.9	7.1	8	8.9	9.8	10.5
LUCF	2.4	2.3	2.2	2.2	2	1.9	1.8
Industrial processes	1.6	1.5	1.8	1.6	1.4	1.4	1.6
Other	2.6	2.6	2.7	2.8	2.8	2.9	3
Total	74.8	75.6	75.6	77.3	77.3	79.4	78.9

Figure 3. Nitrous oxide emissions, percentage change from 1990, by sector



D. New gases

31. According to the NC2, perfluorocarbons (PFCs) generated in the production of aluminium were estimated at 210,000 Gg in 1995, a 720,000 Gg decline since 1990 as a result of processing improvements. Estimates of HFCs and SF₆ were still being finalized at the time of the review and are expected to be available later in 1999.

III. POLICIES AND MEASURES

32. Outlined in the NC2 are the policies, measures and mitigation benefits of the NGRS, and the Greenhouse 21C, a 1995 supplementary Commonwealth GHG abatement programme to the NGRS, grouped on a gas-by-gas and sector-by-sector basis. Key policy actions taken thus far by the Commonwealth Government are also presented, as well as information on each measure and its estimated effect on reducing GHG emissions with the significant reductions quantified. The team felt that Australia had adequately adhered to the FCCC guidelines for the preparation of national communications. Regular reports on implementation of NGRS measures were produced as specified in the NGRS. National performance indicators were adopted by Governments and are reported upon in a trends assessment report. HFC and SF₆ emissions are covered by the Greenhouse Challenge Program and measure 7.2 of the NGS. Overall, with the inclusion of details on the Prime Minister's package, sufficient information was provided to reliably guide the team in its evaluation of GHG policies and measures now in place. The review team also noted that, although there was no national system to comprehensively monitor and report on the progress of policy initiatives across sectors, some specific programmes were periodically reviewed to gauge their progress and accomplishments.

33. When the NC1 was published in 1994, it reported that, without measures, GHG emissions would increase by 14 per cent between 1990 and 2000, a doubling from the 1992 NGRS forecast of 7 per cent. But by 1995, with the advent of new mitigation and sink enhancements proposed under the Greenhouse 21C programme, estimated emissions growth was

3 per cent, if all existing and planned measures were fully implemented. Approximately 70 per cent of the reductions were expected from cooperative agreements with industry, most relying on voluntary, cost-effective initiatives - meaning no-regret activities. There were few regulatory initiatives and no measures that made use of fiscal instruments. The following strategies formed the mainstay of the NGRS: alternative fuel use in the transport sector; energy efficiency measures (partly voluntary agreements with industry); and the development of a sweeping energy policy which, among other things, had increased support for renewables research and commercial application.

34. In March 1995, a new national plan to mitigate GHG emissions was introduced. At its core was the Greenhouse Challenge Program, a central feature of its NGRS. The GCP is focused on voluntary reduction agreements with individual firms. While the voluntary approach has had some success, Australian experts explained that their experience with the general NGRS framework eventually led them to conclude that voluntary action alone may not be enough in themselves to reduce emissions to meet Australia's target. As a result, a number of new, apparently cost-effective and innovative initiatives have been announced since the publication of the NC2. These initiatives focus on accelerating reform of the energy sector, and other means of lowering GHG emissions. Instituting energy efficiency standards for power generation, improving motor vehicle fuel efficiency by 15 per cent above 1995 levels (national average fuel consumption target), adopting building codes and standards, and fostering plantation forestry and native re-vegetation are but a few examples of this expanded approach.

35. With respect to the energy sector, Australia has become a large energy exporter since the early 1970s, mainly due to the development of coal and gas exports. In 1996, the share of energy exports was 48 per cent of national production. Two thirds of coal production and one third of gas production are exported. Australia is a net importer of oil. The team was informed that the Australian Government has been recently undertaking, considerable regulatory reform of the economy and in particular of the energy sector. As Australia is a federation, the Commonwealth Government has relatively limited constitutional powers regarding energy policy. Consequently there is a constant need to coordinate Commonwealth and State energy policies.

36. The electricity systems in the States and Territories have developed independently over time, and were largely designed to satisfy the electricity demand within their boundaries. For this reason, as well as the country's geographic size, the electricity sector differs widely across States insofar as overall industry structure, total capacity, fuel mix, and grid density are concerned. To correct this situation, improve operations and increase operational efficiency, the Commonwealth Government, together with the States, has been undertaking substantial restructuring of this sector. A competitive electricity market is currently being introduced between the interconnected States of eastern and south-eastern Australia. A national regulator was established and a National Electricity Code was promulgated in 1997. States are undertaking structural reform of their utilities such as unbundling, corporatization or privatization. Victoria and New South Wales have taken the lead by implementing a wholesale competitive market, which constitutes the first stage of the interstate market. They are expected to be followed in 1999 by other States in eastern and southern Australia. Major improvements are expected from the reforms in the electricity sector. Electricity plants are expected to be more efficient due to increased

competition, and the phasing-out of cross-subsidies will lead to more rationality in prices. There will also be an improvement in fuel switching resulting from the removal of regulations which were an impediment to the development of gas and renewables for electricity generation.

37. Coal is Australia's largest energy resource and over two thirds of its reserves of 766 million tonnes are commercially recoverable. Australia is also the world's largest hard coal exporter, capturing about 30 per cent of the world market. States own the coal reserves within their boundaries, with New South Wales and Queensland mining almost 90 per cent of national production. Coal predominates in electricity generation and its share nationwide has grown over the past two decades from 75 per cent in 1973 to more than 80 per cent in 1995. Currently, coal accounts for 98 per cent of electricity generation in Queensland, 93 per cent in New South Wales, 90 per cent in Victoria, and 75 per cent in Western Australia, as most coal mines are also found in these States. On the other hand, natural gas accounted for 98 per cent of electricity generation in the Northern Territory and hydropower almost 100 per cent in Tasmania, in 1995. The team was informed that the recent Asian financial crisis has had an adverse impact on the Australian coal industry, and in order to increase the competitiveness of Australian coal, the Commonwealth Government is considering reforming industrial relations and commercial trade arrangements. The coal-exporting States are implementing reforms to reduce rail freight rates and to improve port operations. As production costs are very low and currently there is overcapacity in the coal industry, all indications suggest growth in coal production, consumption and exports.

38. The natural gas market in Australia has been growing steadily since the 1970s. Natural gas accounted for 18 per cent of primary energy supply in 1996 and its consumption more than doubled since 1970. Most of the gas supplied is consumed by industry and for power generation. Most States and Territories have access to significant gas resources within their own boundaries or in adjacent offshore areas which are under Commonwealth jurisdiction. With the exception of Tasmania, which consumes no natural gas, and New South Wales, which is supplied with gas from South Australia, all other States and Territories produce sufficient amounts of gas for their own uses. Natural gas consumption is indeed growing faster than any other primary energy source, in spite of barriers to interstate trade impeding even more rapid market growth. The team learned that the federal and state/territory governments are working on the implementation of wide-ranging regulatory reforms to establish a more competitive natural gas industry and since the adoption of the Natural Gas Strategy in 1991, progress has been made, in such fields as: removing barriers to inter- and intra-state trade in gas, particularly those which constitute barriers to the entry of new competitors; promoting market access through a national regulatory framework involving the establishment of third party access rights to pipeline networks and other facilities; unbundling of gas transportation activities; development of a national pipeline grid; and the removal of cross-subsidies between customer categories.

39. Regulatory reform is expected to contribute significantly to the development of the gas industry in removing barriers as well as deriving benefits, including increased supply security, increased interfuel competition and consumer choice, lower unit gas supply costs and consumer

prices and lower GHG emissions, to the extent that gas replaces more carbon-intensive fuels such as coal and oil.

40. Australia is the world's second largest producer of uranium after Canada, and accounts for nearly 30 per cent of uranium resources in the world. Although it produces 11 per cent of total global uranium output, there is no nuclear programme owing to strong public opposition to its development. The bulk of uranium produced is exported for nuclear power generation.

41. Australia is about 80 per cent self-sufficient in oil. In 1995 most of the oil production came from offshore basins, although there are still a considerable number of small onshore fields. The team learned that since 1995, no large oilfields have been discovered and proven oil reserves, estimated at 400 MTOE in 1995, are equivalent to approximately 15 years of consumption. As a result of an increase in local consumption, net oil imports have grown in the last 10 years. Whereas in 1986 Australia was a net oil exporter, about 10 per cent of domestic oil production has been imported annually since 1995. The national oil industry has undergone restructuring since 1994 in order to remain competitive especially in the Asian markets, in the face of low world oil prices. While exploration and production activities already operate in a deregulated market, the main issue in the oil industry is the refining, distribution and wholesale and retail sales regulation. The downstream segment, which is highly regulated by both the Commonwealth and state governments in terms, for example, of wholesale price controls of some fuels and access to storage facilities, is expected to undergo reform in the near future.

42. Commonwealth government experts have stated that energy supply reform will result in significant future CO₂ emission reductions, without providing specific details of how this will be accomplished. With removal of some legal restrictions it is not clear to the review team what the cumulative effects of such developments will be on future GHG emissions - although in all likelihood they will have a net beneficial impact through efficiency gains and fuel switching.

43. At the sectoral level, the team felt that the Greenhouse Challenge Program, which was launched in 1995, is one of the most concrete proposals for the industrial sector, and covers industries responsible for approximately 45 per cent of GHG emissions. Industrial energy consumption in 1995 accounted for 39.3 per cent of final consumption, energy use having increased steadily from the early 1980s as a direct consequence of a structural shift in the economy to more energy-intensive industries. The national experts felt that the GCP is a highly successful undertaking and that remarkable progress has been made since the preparation of the NC2 in formalizing voluntary agreements with industry, and, in particular, putting in place a system to effectively monitor their performance. The first agreements under the GCP were signed in June 1996. On signing an agreement, each company agrees to prepare an inventory of its emissions and a specific greenhouse action plan, forecast emission levels, undertake monitoring and reporting, verify performance, and make a public statement on the company agreement. Since its launching over 250 of Australia's largest companies comprising firms in the energy, resource processing, mining and manufacturing sectors, along with industry associations, have committed themselves to the GCP and 116 industries have actually signed agreements. The GCP is forecast to reduce growth in industrial emissions by 24.2 Gg CO₂ equivalent.

44. GCP representatives explained that the programme is now expanding. Initially, it focused on large energy-intensive industries, but since 1998 medium-sized businesses have been included. The goal of the programme is to absorb 500 companies by 2000 and more than 1000 companies by 2005. As part of this initiative, the "Managing Energy for Profits Program" was developed to assist and expedite the involvement of hundreds of smaller companies across Australia, whose energy costs per industry are up to \$A 200,000 per year and which could reduce total GHG emissions through improved energy management. Therefore the bulk of signatories in 1999 would include businesses from the hospitality, food, metals, textiles, and transport industries. Half of the companies already participating are expected to stabilize their 2000 emissions at or below 1995 levels, despite continued business growth, and to reduce their emissions growth by 10 per cent. This will limit their combined emissions in 2000 to 115.5 million tonnes of CO₂ equivalent, a 16 per cent (22,000 Gg) reduction from a position of "no action".

45. The NC2 listed 10 measures aimed at reducing energy use in the transport sector, and thereby reducing GHG emissions. Inventory data in 1996 showed that CO₂ emissions from transport accounted for 17 per cent of total net emissions. Final consumption of energy in the sector has increased faster than in any other sector over the past 20 years, its share increasing from 32 per cent in 1973 to 39 per cent in 1995. This trend has been influenced by lower urban population densities and decentralized land-use patterns, increasing the reliance on cars. Although gasoline and diesel consumption per passenger car have decreased by 6.6 per cent and 14.5 per cent respectively between 1991 and 1995 (a slower rate of decrease than the average for countries of the International Energy Agency (IEA)) Australia now ranks third in transport GHG emissions per capita, after the United States of America and Canada, and the proportion of car ownership in Australia is substantially higher than the IEA average. Fuel prices are also lower than in most other IEA countries due to lower fuel taxes, thereby encouraging greater automobile travel.

46. Given that the automobile accounted for 87 per cent of total passenger-kilometres travelled in urban transport, it is not surprising that many initiatives use public awareness as a tool to promote a shift to public transport and promote integrated transport planning. Specific programmes over the years have included driver education, reducing speed limits in South Australia and New South Wales and Queensland, introducing alternative public transport such as the "midi-van" and the commuter-express bus service in the Australian Capital Territory, the South East Queensland citytrain, the opening of a light rail system in Sydney, and improvements to urban train services in Melbourne. In an effort to optimize the use of low-emission rail transport, the Commonwealth Government allocated \$A 2 billion to upgrade rail services and is encouraging greater private sector involvement, so as to create a more competitive and efficient environment in the rail freight industry by introducing more lines and lower tariffs. Complementary reforms and rail system upgrading are taking place in Queensland, New South Wales, Victoria, and South and Western Australia.

47. As part of the 1997 Prime Minister's package, a Commonwealth "Environmental Strategy for the Motor Vehicle Industry" was announced in a renewed effort to address GHG emissions in

automobiles. Prior to this, the vehicle industry concluded in 1995, a non-mandatory agreement for a national average fuel consumption target for new (local and imported) passenger cars of 8.2 litres per 100 km by 2000, compared to the IEA average of 8.9 litres per 100 km. The new strategy will cover mandatory fuel efficiency labelling through Australian Design Rules for all new cars for all new cars for sale in Australia and a strengthened national average fuel consumption target for 2010 which requires a fuel efficiency improvement of 15 per cent above business as usual by 2010. New options for improving vehicle fuel consumption are expected to be investigated from 2003.

48. Also under the 1997 Prime Minister's package is a component called "Alternative Fuels for the Transport Sector", under which the Commonwealth Government, in collaboration with local government authorities and natural gas companies, will establish a network of compressed natural gas service stations, in particular for light commercial and heavy vehicles. Other alternative transport fuels under investigation are liquefied petroleum gas (LPG), ethanol from biomass, methanol from biomass and natural gas, seed oils and hydrogen. The team was informed that these fuels, as well as equipment for converting vehicles to LPG or natural gas, are currently exempt from Commonwealth taxes. This context will change with the introduction of the Commonwealth "A New Tax System" package but the impact of any new taxes will be offset by the Alternative Fuels Conversion Program, to commence in July 2000.

49. The commercial and residential sectors accounted for 43 per cent of direct energy-related GHG emissions in 1996. In terms of total energy end-use, these sectors accounted for about 28 per cent of total energy-related GHG emissions in 1996. The NC2 mentioned five key measures aimed at improving energy end-use efficiency: energy performance codes and standards for domestic appliances and industrial equipment; energy efficiency programmes for households including a nationwide House Energy Rating Scheme; energy efficiency improvements in government operations; minimum energy performance standards for commercial buildings; and bench-marking energy efficiency. These programmes have been incorporated within the National Greenhouse Strategy. The appliances and industrial equipment programme has been strengthened, and the National Appliance and Equipment Energy Efficiency Committee provides a framework through which governments can coordinate the development and implementation of tasks such as energy labelling and minimum energy-performance standards. While the regulatory powers remain with the States and Territories, the Commonwealth plays a leadership and coordinating role. Government and industry have agreed to address new and refurbished residential and commercial building energy efficiency through a combination of mandatory minimum energy performance codes and standards and voluntary industry best practice codes.

50. The NC2 listed both Commonwealth- and State-supported renewable energy projects that are expected to have measurable effects on GHG emissions. The Commonwealth Government is funding an ambitious set of renewable energy initiatives that includes the following: the Australian Cooperative Research Center for Renewable Energy and Related Greenhouse Gas Abatement Technologies; the International Center for the Application of Solar Energy; the Renewable Energy Industry Program; and the "EnergyCard", which provides a low-interest credit

facility for people who want to purchase renewable technology and energy efficient equipment. This novel venture was established by the Commonwealth Government in cooperation with industry, distributors and financial institutions, and was reported to the team as being quite successful.

51. The team was informed that, in its effort to boost the use of renewable energy nationwide, the Prime Minister's package has several new measures. The most prominent is a mandatory target for electricity retailers and other large buyers to source an additional 2 per cent of their electricity from renewable energy by 2010. This policy will speed up the use of renewable energy for grid-based power, from its level of 17 TWh of electricity in 1995. This represents an increase of between 2,000 and 4,000 MW of new installed capacity by 2010 in order to produce the expected 9,000 GWh required to meet the target. This will increase Australia's renewable energy component in electricity generation from 10.5 per cent to 12.5 per cent by 2010. Although the combined effects of these efforts on GHG mitigation have yet to be fully estimated, the team agreed that substantial mitigatory effects were probable.

52. Another initiative is the establishment of the Renewable Energy Equity Fund, under which public and private funding will be used to assist small, innovative companies to commercialize renewable energy technologies. Still another financial measure is the establishment of two grants programmes, the Renewable Energy Showcase and the Renewable Energy Commercialization Program (RECP). The RECP has \$A 30 million of funding to be allocated over 3 years. This is an addition to funding under the existing Renewable Energy Industry Program. The RECP is significant in that it will provide grants normally in the range \$A 100,000 to \$A 1m to support the demonstration and commercialization of renewable energy technologies such as solar thermal, photovoltaics, or for biomass to energy. The Renewable Energy Showcase is a one-off program that provides grants totalling \$A 10 million to 5 innovative programmes to showcase Australian renewable energy.

53. The Australian experts explained that, although many initiatives in the agriculture and forestry sectors are well established, many did not specifically have as their original basis GHG mitigation, but increasingly land use policies and programmes are integrating greenhouse outcome with other objectives. One of the key objectives of the Commonwealth Government is the sustainable use of natural resources, including sustainable agriculture and land-use, and improving natural resource management, one sub-objective being to reduce GHGs. The most noteworthy initiative mentioned in the NC2 is the Natural Heritage Trust, capitalized with \$A 1.5 billion over six years. The Natural Heritage Trust is a prime component of the Commonwealth Government's mitigation of GHGs associated with land-based activities. It includes Bushcare (budget: \$A 347 million); the National Landcare Program (\$A 327 million); the Farm Forestry Program (\$A 49 million); the National Rivercare Program (\$A 87 million); Murray-Darling 2001 (\$A 196 million); and the National Wetlands Program (\$A 17 million). Landcare and extension activities promoting sustainable land management, funded under the Trust, which is already well under way, are expected to have a mitigation impact of 4,400 Gg of CO₂ equivalent by 2005, and another 2,300 Gg by 2010.

54. The team was also informed that there are many other cost-effective opportunities to enhance sequestration in forests and native vegetation. The NHT's Bushcare and Farm Forestry programmes and the Bush for Greenhouse initiative, announced under the Prime Minister's November 1997 package, are expected to contribute a further reduction of 7,900 Gg of CO₂ equivalent by 2005. In addition, the Commonwealth Government, under the Prime Minister's package, has announced that under the programme, Plantation for Australia - the 2020 Vision, it will fund key actions necessary to triple the size of Australia's forestry plantation estates by increasing the current plantation establishment rate from 20,000 to 80,000 hectares per year, until 2020. It was also estimated that under the National Strategy for Rangeland Management, developed to deal with the use and conservation of Australia's arid, semi-arid and tropical zones, more than 300,000 Gg of organic carbon could potentially be restored by rehabilitating deteriorated pastures on rangelands in northern Australia over a 30-year period through a change in management practices.

55. Although the Commonwealth Government has no constitutional jurisdiction over land clearing, this is being progressed under the National Framework for the Management and Monitoring of Australia's Native Vegetation, an initiative of the Australian and New Zealand Environment and Conservation Council (ANZECC). ANZECC is the Council of the Australian Commonwealth, State and Territory and New Zealand ministers with responsibility for conservation and the environment. The team was informed that some state governments are already working in this area. For example, New South Wales has control over the most sensitive areas of the state; Victoria controls the clearance of native vegetation; Queensland is nearing completion on guidelines for tree clearing on leasehold land; Western Australia introduced measures in 1995 to improve the protection and management of remnant vegetation on private agricultural land.

56. The NC2 described eight measures for reducing CH₄ emissions, including methane capture from landfills, which has been implemented. The remaining seven measures involve oil and gas, coal seams, and agriculture. The review team noted that a combination of statutory guidance, research, commercialization, and voluntary industry actions for reducing CH₄ were being used. Most of the CH₄ abatement is expected to be in the field of fugitive fuel emissions between 2005 and 2010, but with reductions also expected from agriculture.

57. Australia has the world's fourth largest coal seam gas resources after the Russian Federation, Canada and China. Gas recovery from coal seams during coal mining is a large potential source of CH₄ reduction, estimated at 1,313 Gg by 2010. The Australian Gas Association has reported that \$A 115 million has been spent over the last nine years on investigating the feasibility of extracting and utilizing this CH₄, either in the natural gas system or directly for electricity generation. Already there are agreements to convert coal seam CH₄ into electricity at two mines in the South Sydney Basin and one in Queensland, mitigating an estimated 6,200 Gg of CO₂ equivalent. Fugitive emissions of CH₄ from oil and gas exploration are declining, leak detection systems and new technologies having already reduced emissions by 10 per cent since 1995.

58. Of the three projects presented for CH₄ mitigation in the agriculture sector, the one with the greatest potential concerns methanogenesis in ruminant livestock. The Commonwealth Scientific and Industry Research Organization (CSIRO) has patented an anti-methanogen feed additive which suppresses methane emissions by up to 100 per cent. Another patent is for a methanogen vaccine that is already achieving an 18 per cent reduction rate. The team also learned that \$A 1 million is allocated under the Prime Minister's package for further research and development. In this area, it is estimated that CH₄ emissions can be reduced by 108 Gg by 2005. The other two measures focus on reducing residue burning and improving manure management. Both contribute marginally to CH₄ reduction.

59. The Green and Organic Waste Management Strategy (1996), agreed to by the Australian and New Zealand Environment and Conservation Council (ANZECC), is directed at reducing and improving on-site management of organic wastes, thus minimizing CH₄ production. The strategy's main thrust is to redirect organic waste away from landfills, and develop new ways to use this waste as mulch, for window composting (aerobic) and for vermiculture. Waste management is a state, territory or local government responsibility and most already employ waste minimization practices, as well as reuse.

60. The NC2 described two measures to reduce emissions of N₂O in the agriculture and LUCF sectors. Both are research oriented. The first involves a reduction in biomass burning and land clearing, while the second is a voluntary programme known as the fertilizer accreditation programme. The latter targets improved fertilizer management by providing farmers with better information on fertilizer application and soil conditions. Representatives from the Ministry of Agriculture informed the team that, although fertilizer use in Australia is comparatively low compared with other OECD countries, there is still scope for improving fertilizer handling.

61. The main source of PFCs is in the production of aluminium. Australian aluminium smelters are already efficient, having achieved a 68 per cent reduction in emissions between 1990 and 1995. According to the NC2, the industry is committed under the GCP to reducing PFC emissions by 80 per cent (from 1990 levels) by the year 2000. Under the National Greenhouse Strategy, work is being undertaken to develop environmental management strategies for HFCs, PFCs and SF₆. Since 1992, codes of good practice have been developed and implemented by every producer in the air-conditioning and refrigeration industry. The result is that CFC and HFC emissions have been reduced to a negligible level. (Only recently the codes were revised to include HFCs). This was done primarily through recycling and optimal recovery techniques.

62. The NC2 reported on innovative local government policies and measures for reducing GHG emissions. The team was informed that local governments are strategically placed to help reduce GHG emissions, and have the capacity to influence activities contributing up to 50 per cent of Australia's national GHG emissions. A key initiative was a pilot project with the Cities for Climate Protection™ Australia campaign, in which participating local governments set a GHG gas reduction target for their own corporate operations and for their broader communities. Corporate actions include improving the energy efficiency of local government buildings,

incorporating energy efficiency in their purchasing policies and capturing CH₄ from landfill sites. This programme has recently been extended into a five year, \$A 13 million initiative, which will recruit up to 200 local governments. Community actions under this initiative include the co-location of industries to share the use of waste products, encouraging the use of public transport, waste minimization and recycling of organic wastes, community information programs, incentives to use renewable energy, and enhancing the sink capacity of forests.

IV. PROJECTIONS AND ESTIMATES OF THE EFFECTS OF MEASURES

63. The NC2 contained a set of projections of GHG emissions for all sectors of the economy and for forestry sinks where gas-by-gas data were available. Estimates expressed in the CO₂ equivalent for all GHG emissions were also presented for all sectors. Estimated emissions were presented on a sector-by-sector basis at five-year intervals from 2000 to 2020, and cover the main GHG gases (CO₂, CH₄ and N₂O). PFC emission forecasts are presented on a CO₂ equivalent basis and are combined with estimates for industrial processes. Since data were not available for HFCs and SF₆ in 1990, projections of these gases are not contained in the NC2. Guidelines for national communications encourage countries to provide projections for international bunker fuels. The NC2 notes that projections for bunker fuels were not estimated. In spite of these omissions, there was consensus by the review team that the methodology and overall data coverage had improved significantly compared with the NC1. In addition, most of the key assumptions were presented in the table format required by the IPCC Guidelines. This made the results and findings of the NC2 much more transparent, especially for comparing and evaluating GHG emission trends by sector.

64. Projections presented included baseline estimates of GHG emissions growth in the absence of policies and measures to reduce growth for each sector. Three scenarios of future emissions were also developed by changing key input parameters and taking into account the impacts of current greenhouse response measures for reducing future emissions - a 'best estimate' (BES), a 'high estimate' (HES) and a 'low estimate' (LES). The projections team explained that the best estimate scenario, which is the one presented in the NC2, is considered the most likely emissions outcome and represents an approximation of average GHG emissions over time and for all sectors, except land-use change.

65. The main NC2 modelling exercise was conducted by the Australian Bureau of Agricultural and Resource Economics (ABARE), a research agency now within the Federal portfolio of Industry, Science and Resources. ABARE worked in close coordination with the Commonwealth Working Group, comprising representatives from specialist government departments, a number of expert consultancies, representatives from academia, and stakeholders. Projection work in the transport sector was carried out by the Department of Transport.

66. Projections for the energy sector presented in the NC2 are based on results generated by three computable general equilibrium models (CGE): the G-Cubed-Dynamic Model; MEGABARE, a global equilibrium model developed in Australia to analyse greenhouse issues,

given the trade-reliant nature of the economy and the Monash models; and the ABARE Fuel and Electricity Survey (FES). In the agriculture sector, an ABARE forecasting model, EMABA, was employed, combined with the technical analyses of the livestock and crop trends of the Bureau of Rural Sciences. Some other technology-oriented models were used in support of the CGEs. In the case of transport, waste and forest sectors, simple trend projections were employed. The end result is a combination of scenarios that are sector-specific and cover the economy at large.

67. The key assumptions used in estimating GHG emissions growth are well documented in the NC2. In the BES for the energy sector, the “rebound effect” (the propensity of financial savings from energy efficiency to be recycled back into the economy, resulting in higher energy consumption and partly offsetting the original saving in money and energy) was quantified (10 per cent of the original mitigation effect for most measures). That is, compared to the prescribed gain in energy efficiency up-front in the projections analysis in NC2, the net efficiency gain was typically 10 per cent less. Only those measures in place by mid-1997 were considered hence, the effects of additional measures captured under the Prime Minister's November 1997 package and the 1998 NGS are not included, although the latter is quoted in the NC2 as delivering 39 Mt CO₂ equivalent emissions savings.

68. Assumptions in the energy sector were built around energy prices, gains in energy efficiency and GDP growth: the world coal price was taken to be constant, with oil prices rising 1.2 per cent annually and energy efficiency improvement set at 0.8 per cent annually. The assumed rate of GDP growth between 1995 and 2010 was fixed at 3.7 per cent annually. Lastly, annual population growth rate was set at 0.91 per cent in the BES.

69. In the NC1, projected baseline GHG emissions in 2000 were estimated at 654,000 Gg of CO₂ equivalent, or 14 per cent above the 1990 level of 572,000 Gg. The 1990 level was revised downward in the NC2 to 380,000 Gg. The NC1 and NC2 pictures for 1990 differ mostly because the NC2 figure does not, as yet, include land clearing emissions. GWPs were changed by the IPCC and this makes a significant difference to GHG emissions expressed as CO₂ equivalents since CH₄ is a substantial part of Australia's emissions profile. Between NC1 and NC2, the inventory methodology has been significantly improved. Baseline projections for the energy sector clearly show emissions growth remaining strong over the forecast period, rising by 48 per cent through 2010 over 1990 levels of 267,300 Gg to 396,000 Gg. The best estimate with current measures in the sector was 316,800 Gg in 2000 and 373,400 Gg in 2010, which is 40 per cent over the 1990 level. Measures proposed under the NGS could provide a further 15,000 Gg of reduction in emissions.

70. The following estimates are based on simple projections of general economic activity. Fugitive emissions of CH₄ from coal mining, venting and flaring during oil production are estimated to reach a combined 42,000 Gg of CO₂ equivalent by 2010, without measures, representing a 66 per cent rise above 1990 levels. With measures, however, emissions rise much less, in the order of only 12 per cent (or 29,000 Gg). Fugitive emissions in the industrial sector - without measures - are projected to increase by 69 per cent through 2010. But, as the sector is a very small contributor to total GHG emissions (1.7 per cent) the impact is marginal. Due to the

gradual shift in coal production from underground mining to less methane-intensive open-cut mining plus a major leak reduction programme in the Sydney gas distribution system, overall CH₄ emissions are expected to decline in future.

71. The NC2 used sensitivity analysis on the "with measures" scenario to test the effect of different macro assumptions on the energy sector. In designing the alternative scenario, GDP growth was lowered (LES) and increased (HES) by 0.5 per cent annually, compared with the BES. In the ABARE commodity forecast, real coal prices are kept flat under the BES, and increasing (LES) and decreasing (HES) by 1.0 per cent annually. World oil and gas prices are on the rise each year, such that by 2020 real prices are 20 per cent above 1995 levels (BES). Simulations were run with the price of renewable energy 50 per cent higher than in the BES for the first five years, after which it falls to a standard price. Conversely, in the HES, renewable prices are 25 per cent lower initially before increasing to a standard price. The annual rate of energy efficiency improvement in the LES rises steadily to 1.6 per cent by 2020, and steadily decreases to 0 per cent by 2020 in the HES.

72. The agriculture sector covers emissions arising from the production of crops and livestock (not counting emissions from land clearing). On a CO₂ equivalent basis, this sector accounted for 20 per cent of total net GHG emissions in 1995. Using the national GHG inventory as the framework for projecting agricultural GHGs, a set of baseline projections was developed for livestock numbers and cropland through 2020, employing the ABARE econometric model EMABA. (This particular model was chosen because the Australian agriculture sector is highly sensitive to exports, and it incorporates recent studies on expected domestic commodity demand and the trade environment over the forecast period). To ascertain the GHG response to agricultural mitigation measures - that is measures currently in-place under the NGRS and Greenhouse 21C, and those likely to be adopted out of the NGS - scenarios were developed based on the type of policy measure, and on its prescribed technical efficiency.

73. The results indicate that the sector will continue to be a growing source of GHG emissions in Australia, increasing by 10 per cent to 98,100 Gg through the year 2010, when, in the absence of measures, emissions are expected to increase. With existing measures, GHG emissions drop by 3 per cent from the baseline by 2010 to 94,900 Gg or 7 per cent above 1990 levels. The projections team noted that a significantly greater emission reduction was possible, or so it would appear, with the adoption of measures arising out of the NGS, which foresees an estimated 13 per cent reduction by 2010. They added that there is a high degree of uncertainty in the agriculture projections, apparently arising from the use of the EMABA model, given that it is designed as a five-year forecasting tool but is being used to forecast over a twenty-year period - thereby reducing its reliability.

74. As part of the sensitivity analysis for the agriculture sector, growth rates in that sector in the BES were tied to gross national product, increasing 3.4 per cent annually from 1996 to 2002, 3.5 per cent from 2003 to 2010, and 2.1 per cent from 2011 to 2020. The explicit assumption here, as was pointed out to the team, is that GDP as a measure of domestic economic activity has very little effect on the bulk of Australian agricultural production, which is exported.

Consequently, exports to overseas markets are the major factor in determining levels of agricultural production and therefore GHG emissions.

75. Projections of emissions emanating from municipal solid waste (landfills) and domestic, commercial and industrial waste water are based on population growth and industrial activity. Without measures, aggregate emissions from waste are expected to grow 51 per cent to 22,400 Gg by 2010, up from 14,800 Gg in 1990. With measures, emissions grow at a slower rate (16 per cent) rising to only 17,200 Gg in 2010. The measures responsible for the decline are waste sorting and minimization; expanding the capture and utilization of landfill gas; and shifting disposal methods from anaerobic to aerobic digestion.

76. Two separate categories were specified in modelling the forestry and land-use sector, one being forestry itself and the other land clearing for agricultural development. The forestry component is defined as managed native forest, forest plantations and re-vegetation. Overall, it is a net GHG sink. The model used for projecting land clearing is based on historical data on land-clearing and associated activities. Baseline emission estimates for the forestry sector through the year 2020 are based on predictions of forest plantation area, the rate of timber harvesting, and fuel consumption. Using data from the national inventory, and assuming that the area of managed forest remains constant, the baseline suggests that the forestry sector will become an increasing but fluctuating sink for carbon, exceeding 25,000 Gg of CO₂ per year by 2010. The baseline estimate, as reported to the team, is solely dependent upon the relationship between future population and roundwood removals. With measures from the NGRS and Greenhouse 21C, respectively, an additional 2,000 Gg and 3,000 Gg of CO₂ per year can be absorbed. Since the experts stated that their analysis was fairly conservative, it is likely that Australia's forested area may prove to be a greater sink than currently estimated. The BES was estimated using an annual forest population growth rate of 0.91 per cent. The measures expected to have the greatest impact on the sink are as follows: One Billion Trees; Save The Bush; Wet Tropics Tree Planting Scheme; River Murray Corridors of Green; and the Murray-Darling Basin Commission Natural Resources Strategy.

77. After extensive discussions with the projections team, it was generally concluded that the GHG projections are based on the best available data and sound forecasting methods, to the extent that they currently exist. Overall, the results indicate annual emissions growth of 1.65 per cent versus GDP growth of over 3 per cent between 1995 and 2020. Commonwealth and State governments, by all accounts, intend to address the problem of GHG abatement with measures already in place and more coming on-stream. The projections team mentioned that the combined effect of measures included in the NGRS, the Prime Minister's package and the 1998 NGS have yet to be quantified.

78. In summary, all else being equal, the 1997 findings show a 43 per cent rise in emissions by 2010 in the absence of mitigation measures, an annual increase of roughly 1.7 per cent. With the measures included in the 1992 NGRS and the Greenhouse 21C programme, a 28 per cent increase is projected (a 1.25 per cent annual rate). Incorporating the measures contained in the

Prime Minister's package will in all likelihood lower emissions growth yet again by a substantial amount, potentially dropping the rate to 18 per cent by 2010, or 0.8 per cent yearly.

V. VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

79. The NC2 provided complete coverage of all key sectors vulnerable to an enhanced greenhouse effect, including agriculture and possible changes in stocking rates, crop yields, vegetation, stream flow and groundwater recharge, distribution of pests, and fire risks. At the same time possible strategies were identified for adapting to these impacts at Commonwealth as well as state and local government level.

80. Australia has in addition been engaged in a large number of sector-based 'sensitivity' studies looking at the effects of climate change on health and welfare (e.g., vector-borne diseases, primary prevention measures), natural ecosystems and biodiversity, and agriculture (cropping and grazing). Integrated impact assessments of climate change have covered such diverse topics as cattle ticks, the snow season and tourism, the coastal zone, the cost to local economies, and bird extinction owing to the loss of wetland nesting areas (for example, the Mcquarrie River Basin, New South Wales, study). Studies have also been conducted on responses to climate change in the areas of energy (improving coal combustion technology, the economic effects of fuel substitution, higher efficiencies in the transport sector), agriculture (lowering methane production and carbon sequestration in soils), and forestry.

VI. RESEARCH AND SYSTEMATIC OBSERVATION

81. As reported in the NC2 and learned firsthand by the team, Australia is engaged in an impressive array of research and monitoring activities on climate change - in fact, its activities are the most comprehensive in the southern hemisphere, spanning work being undertaken by CSIRO, the Bureau of Meteorology, many universities, cooperative research centres, and other organizations. After reviewing Australia's activity in research and observation, the team agreed that the country is undertaking an ambitious and proportionally large share of work related to all aspects of climate change, and that the reporting guidelines have been respected in this area.

82. National research into global climate change and its regional impacts has been underway since the 1970s, and includes research into atmospheric, oceanographic, hydrological, and biospheric aspects of the climate system; the development of global and regional climate models; and the integration of carbon cycle processes, monitoring and modelling. The CSIRO significantly advanced capacity to remotely sense land clearing using Landsat MSS data. Areas of clearing were related maximum potential site biomass and anticipated soil carbon loss.

83. Internationally, Australia's contribution to climate research and monitoring is extensive. Much of it has played a large role in, and in support of, the work of the IPCC. Other organizations in which Australia is involved are: the World Meteorological Organization, the World Climate Research Programme, the International Geosphere-Biosphere Programme and the Global Climate Observing System. Research is being conducted on climate and ocean

observation and detection, global atmospheric energy as it relates to the water cycle, ocean circulation, the arctic climate, climate variability and predictability, terrestrial ecosystems, atmospheric chemistry, and past global climate changes. It has been announced in the Federal Budget, 1999-2000, that research into climate change systems to help Australia meet GHG reduction targets will be supported by \$A 14.2 million in Greenhouse Science funding over the next four years.

VII. FINANCIAL ASSISTANCE AND TECHNOLOGY TRANSFER

84. The NC2 provided a detailed and comprehensive description of action taken by Australia in providing financial assistance and facilitating technology transfer related to climate change. Australia's contribution in both areas has been channelled through multilateral development institutions, as well as bilateral initiatives undertaken in developing countries. Although its financial assistance is reported on an annual basis, the review team noted that as was the case with most countries the NC2 did not specify what part of these resources was "new and additional", as required by the UNFCCC guidelines for the preparation of national communications. In spite of this omission, the review team felt that the information in the NC2, as well as discussions held during the review week, demonstrate Australia's outstanding package of financial assistance and technology transfer.

85. Under contributions to multilateral organizations, Australia provided funding to the Global Environment Facility (GEF), the World Bank, the Asian Development Bank, the United Nations Development Programme and the IPCC. The reported commitment to the GEF of \$A 72.76 million covered the GEF pilot phase and GEF1. Since the review Australia has committed an additional \$A 43.27 million to GEF 2, making a total commitment of \$A 116 million.

86. The Australian Government, through the Australian Agency for International Development (AusAID), provides a range of assistance in developing countries for activities related to mitigating climate change, particularly in the Asia-Pacific region. As at May 1999, the estimated overseas aid budget for 1998-9 was \$A 1.478 billion, which is \$A 25 million more than the final expenditure of \$A 1.453 billion in 1997-98 (1998-99 constant prices). This is a real increase of 1.7 per cent. The ratio of ODA to GNP is 0.27 per cent, which is above the 1996 donor average of 0.25 per cent, and experts explained that ODA as a percentage of total federal government expenditure is expected to rise to 1 per cent in the near future.

87. More than 30 bilateral climate-related projects are supported by AusAID. Most of the projects concern issues such as energy efficiency, renewables, enhancement of forest sinks, agriculture, and waste management. Australia has also integrated environmental concerns into a special set of development assistance projects for vulnerable small-island States in the Pacific. The NC2 listed five key projects: the National Forestry and Conservation Action Program Trust Fund in Papua New Guinea (\$A 7.2 million); the Pacific Island Forests and Trees Support Program (regional: \$A 600,000); the Sea Level and Climate Monitoring Project (regional: \$A 13.5 million); the South Pacific Forum Secretariat's Energy Program (now based with the

South Pacific Applied Geoscience Commission, SOPAC); and the Provincial Rural Renewable Energy Electrification System in the Solomon Islands (\$A 237,300).

88. Also, Australia has a relatively large programme of mitigation measures to "promote, facilitate and finance access to, or transfer of, environmentally sound technologies". Notable projects include a \$A 37 million municipal solar project in the Philippines; solar water heaters in Zimbabwe (\$A 50,000); small solar photovoltaic rural systems in 1000 homes in Sri Lanka (\$A 600,000); and a \$A 4 million ASEAN contribution for countries developing fluidized-bed combustion technologies using industrial biomass residue.

89. With regard to activities implemented jointly (AIJ) under the UNFCCC, the NC2 describes Australia's success in launching the International Greenhouse Partnerships, which complements its domestic Greenhouse Challenge. In October 1996, the IGP office was established and is now providing advice and support services. In addition, the Prime Minister's package allocates extra funding for the IGP office to assist businesses with the additional cost of undertaking AIJ projects. AIJ links have been successfully established with Indonesia and the South Pacific region in areas such as solar photovoltaic in Fiji and energy efficiency in the Solomon Islands.

VIII. EDUCATION, TRAINING AND PUBLIC AWARENESS

90. A cornerstone of Australian policy is the raising of public awareness on climate change issues, with the goal of attaining far-reaching social and corporate commitment to reducing emissions and changing behaviour. The overall strategy in this regard is undertaken by all three levels of government (Commonwealth, state and territory, and local), by industry, and by non-government agencies, with each being responsible for specific initiatives - which are too numerous to mention. In the recently completed 1998 NGS, each module of the strategy deals with a different greenhouse-related subject. Modules 2 and 3 of the strategy are particularly pertinent to disseminating climate change information and education, although each module to a degree targets the overriding need to inform and educate the public and industry. Module 2, "Understanding and Communicating Climate Change and its Impacts", contains a specific plan of action for further developing community understanding through both national information programmes and the entire education system.

91. Besides raising general public awareness of the NGS and coordinating a national approach to information programmes, one of Australia's main goals is to get more people to take part in the national greenhouse response. Australia is establishing a national greenhouse information service, which is intended to provide broad community access to regular, authoritative monthly bulletins on the whole range of climate change issues confronting Australia. The bulletins will report on initiatives in the NGS, progress in implementing mitigation measures, climate change monitoring and detection, GHG emission performance, scientific developments (e.g. in IPCC, CSIRO), and international developments in greenhouse policy. Significant information about climate change activities can be found on the website of the Australian Greenhouse Office (<http://www.greenhouse.gov.au/>). The National Landcare Program has been adapted in the 1998 NGS so as to better identify appropriate target groups for

improving their knowledge of climate change issues, and to identify and evaluate opportunities for delivering more information on climate change.

IX. CONCLUSIONS

92. An assessment of the 1992 National Greenhouse Response Strategy led the Commonwealth, State and Territory governments to conclude that their current actions under that strategy will be insufficient for Australia to meet the UNFCCC aim of reducing GHG emissions to 1990 levels by the year 2000, and that enhanced, strengthened and more broad-based national responses are imperative for achieving their GHG reduction commitments under the Kyoto Protocol. To this end, a substantial package of measures was introduced in November 1997 for addressing all sectors and sinks and the 1997 National Greenhouse Strategy was approved by Parliament in December 1998, which together constitute a step beyond the voluntary policy approach of "no-regrets" by introducing regulatory measures, fiscal stimuli and market-oriented action.

93. While the assessment of the implementation of the 1992 NGRS indicated a degree of progress in implementing greenhouse mitigation measures, there was consensus that the establishment of the Australian Greenhouse Office in 1998, and its mandate to oversee and coordinate domestic action on climate change will substantially strengthen Australia's greenhouse response activities. This will be augmented by the systems being put in place to review the accomplishments of programmes, so that timely adjustments can be made to improve mitigation efforts, as required. The development of the National Carbon Accounting System by the AGO, for future reporting and for quantifying the large uncertainties associated with cataloguing GHG emission sinks and sources in land-use change - specifically land clearing, forests and agriculture - was considered by the review team as an important step in this regard.

94. Including all emission sources and sinks (except land clearing), and without any measures in place, Australia's net emissions growth was projected to increase by 43 per cent over the 1990 level by 2010. With some measures already in place, total GHG emissions are projected to increase 28 per cent (equivalent to 110,000 Gg of CO₂) between 1990 and 2010. The 1997 package of greenhouse measures restricting emissions growth to 18 per cent over the same period (the latest projection) and to meet Australia's Kyoto Protocol target of limiting this growth to 8 per cent relative to 1990 in the commitment period 2008-2012, includes, among others, increasing Australia's sink capacity by trebling plantation forestry estate by 2020, expanding the Greenhouse Challenge Program with industry, to cover over 500 industries by 2000 and 1000 by 2005, achieving greater fuel efficiency improvements in automobiles and implementing a policy mandating electricity suppliers to derive an additional 2 per cent of their supply from renewable sources. However, the review team felt that there is still large uncertainty as to the future CO₂ emission reductions associated with energy supply reform, as specific details of how this will be accomplished were unclear, although national experts believe that, it will have a net beneficial impact through efficiency gains and fuel switching. Similarly, the team believes that measures outlined for GHG reduction in the transport sector may have to be strengthened to achieve expected emission reductions.

95. The team commends the substantial array of research on GHGs, that is being conducted by Australia in the southern hemisphere, coupled with the fact that climate change research seems closely tied to the development of national policy. However, those involved acknowledge that there is a gap between scientific opinion and views held by the general public on GHGs and global warming, and that a concerted effort will be required to change consumer behaviour. Both researchers and policymakers, as evidenced by recent initiatives, have recognized this shortcoming and are devoting additional resources to the problem.

96. Australia's work on the commercial application of solar thermal power and photovoltaics is especially noteworthy and has been replicated successfully. As part of Australia's strategic plan to transfer technology and best practices to developing countries, its work in the Asia-Pacific and South Pacific region to cut emissions, promote environmentally sound technology and industry, and raise public awareness is also commendable.
