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# REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF AUSTRALIA SUBMITTED IN THE YEAR 2000[1]

**(In-country review)**

## A. OVERVIEW

### 1. Introduction

1. The Conference of the Parties (COP), at its fifth session, by its decision 6/CP.5, requested that the secretariat conduct individual technical reviews of greenhouse gas (GHG) inventories for a limited number of Annex I Parties over a trial period. These reviews were conducted according to the UNFCCC Guidelines for the technical review of GHG inventories from Annex I Parties.[2] In so doing, the secretariat was asked to coordinate the technical reviews and to use different approaches including desk reviews, centralized reviews and in-country reviews.

2. Australia volunteered for an individual, in-country review which took place from 4 June to 8 June 2001 in Canberra, Australia. In accordance with review guidelines, the individual review was carried out by a team of nominated experts from the roster of experts, and was coordinated by the secretariat. Participating experts included Mr. Phillip Acquah (Ghana, lead author), Ms Nasreen Farah (Pakistan), Ms Natalya Parasyuk (Ukraine), Ms Helen Plume (New Zealand), Mr. Perry Lindstrom (United States, lead author), Mr. Yousay Hayashi (Japan), Ms Katia Simeonova (UNFCCC secretariat) and Ms Rocio Lichte (UNFCCC secretariat).

3. At the beginning of the review, the host country officials provided a general overview of inventory preparation, including institutional arrangements, followed by presentations by sector. Thereafter, sessions for industrial processes (IP) and waste, and land use change and forestry (LUCF) were conducted in parallel, followed by sessions on energy and agriculture also conducted in parallel. During these sessions national inventory experts further clarified the key issues relating to inventory preparation and this was followed by a question and answer session. These sessions enabled the expert review team (ERT) to gain a better understanding of Australian approaches to inventory preparation.

4. Prior to the in-country review, a synthesis and assessment (S&A) report was compiled by the secretariat based on the information on GHG emission inventories submitted by Parties in 2000. In the report, the secretariat also considered, for each individual Party, those source categories that are *key sources* in terms of their absolute level of emissions, applying the tier 1 assessment as described in the Intergovernmental Panel on Climate Change (IPCC) Good

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[1] In the symbol of this document, 2000 refers to the year the inventory was submitted, and not to the year for which the emission estimates apply. The number (2) indicates that for Australia this is an in-country review report.

[2] Document FCCC/CP/1999/7, in particular the UNFCCC Guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention (pages 109 to 114), and decision 6/CP.5 (pages 121 to 122).

Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, hereafter referred to as the Good Practice Guidance.[3] The preliminary findings and Australia's response to the issues raised in the S&A report for all sectors were discussed during the respective sessions.

## 2. Emission profile and trends

5. Australia's emission profile reflects a reliance on coal-powered electricity, energy intensive commodities (e.g. metals, food and fibre), and a LUCF sector that constitutes a net emissions source. In 1998, energy is the most important sector, contributing 75 per cent of total emissions, followed by agriculture, 19 per cent and finally by waste and IP, with shares of 3 and 2 per cent respectively.[4] The most important gas is $CO_2$, which in 1998 accounted for 70 per cent of total emissions, followed by $CH_4$, 24 per cent and $N_2O$, 6 per cent. Emissions of fluorocarbons contributed only 0.3 per cent of the total. The above calculations exclude the $CO_2$ emissions from the LUCF sector. If $CO_2$ emissions from LUCF are considered, total emission estimates for 1998 are 519,878 Gg, 7.3 per cent higher than the estimate of 484,704 Gg that does not include land clearing. Most of the additional emissions were contributed by the $CO_2$ emissions from land clearing.

6. Tables 1 and 2 provide data on emission trends, correspondingly, by gas and by sector. Emissions of $CO_2$ grew by 21 per cent between 1990 and 1998, driven mainly by energy industries. Emissions of $N_2O$ increased by 23 per cent for the same period due to growth from agriculture and transport. Emissions of $CH_4$ remained largely unchanged, as declines from agriculture and LUCF almost offset the increase in the energy sector for the period.

**Table 1. GHG emissions by gas, 1990-1998 (Gg)**

| GREENHOUSE GAS EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | |
| Net $CO_2$ emissions/removals | 348,761 | 323,643 | 322,711 | 323,762 | 326,261 | 337,654 | 350,232 | 356,081 | 373,146 |
| $CO_2$ emissions without LUCF | 278,669 | 280,206 | 282,769 | 286,296 | 290,367 | 302,277 | 312,286 | 319,532 | 337,973 |
| $CH_4$ | 117,122 | 115,092 | 114,985 | 113,526 | 111,854 | 113,445 | 114,341 | 115,138 | 117,518 |
| $N_2O$ | 22,618 | 22,735 | 23,002 | 23,703 | 24,161 | 24,549 | 24,946 | 26,217 | 27,795 |
| HFCs | NE(*) | NE | NE | NE | NE | NE | NE | NE | NE |
| PFCs | 4,826 | 4,826 | 3,581 | 3,147 | 2,048 | 1,432 | 1,284 | 1,135 | 1,415 |
| $SF_6$ | NE | NE | NE | NE | NE | NE | 9 | 6 | 4 |
| **Total (with net $CO_2$ emissions/removals)** | **493,327** | **466,297** | **464,280** | **464,138** | **464,325** | **477,080** | **490,811** | **498,577** | **519,878** |
| **Total (without $CO_2$ from LUCF)** | **423,235** | **422,860** | **424,337** | **426,671** | **428,430** | **441,703** | **452,866** | **462,028** | **484,704** |

(*) NE: not estimated.

[3] According to a conclusion of the SBSTA at its 12th session, Parties should apply the Good Practice Guidance as far as possible for inventories due in 2001 and 2002, and should use it for inventories due in 2003 and beyond. Following the Good Practice Guidance, the key source analysis was performed by the secretariat at the recommended level of detail. When Parties start the application of this guidance (2001), they may use a different level of category disaggregation for the identification of their key sources according to the Tier 1 Level Assessment (chapter 7 of the guidance).

[4] In this report, the term "total emissions" refers to aggregate national emissions in $CO_2$ equivalents, excluding $CO_2$ emissions from LUCF, unless otherwise specified.

**Table 2. GHG emissions by sector, 1990-1998 (Gg)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | |
| 1. Energy | 299,565 | 301,017 | 305,104 | 307,757 | 310,876 | 325,241 | 335,778 | 343,286 | 362,858 |
| 2. Industrial processes | 12,044 | 11,682 | 10,419 | 10,221 | 9,827 | 8,957 | 8,959 | 8,836 | 9,831 |
| 3. Solvent and other product use | NA(*) | NA | NA | NA | NA | NA | NA | NA | NA |
| 4. Agriculture | 90,595 | 90,870 | 89,435 | 89,003 | 88,176 | 88,175 | 88,410 | 89,927 | 92,202 |
| 5. LUCF | 76,253 | 47,528 | 43,944 | 41,447 | 39,797 | 39,376 | 42,228 | 40,855 | 39,488 |
| 6. Waste | 14,870 | 15,201 | 15,378 | 15,710 | 15,649 | 15,330 | 15,436 | 15,672 | 15,499 |
| 7. Other | NA | NA | NA | NA | NA | NA | NA | NA | NA |

(*) NA: not applicable.

## 3. Data sources

7. The expert review team (ERT) reviewed the *National Greenhouse Gas Inventory Report* (NIR) (1998), the supplementary report *National Greenhouse Gas Inventory – Land Use Change and Forestry Sector* (1990-1998) and the common reporting format (CRF) tables for all years from 1990 to 1998 submitted in April 2000. Other supporting documents were provided during the review. The most important of these documents were *1998 Workbooks for Fuel Combustion Activities (Stationary Sources), Fugitive Fuel Emissions (Fuel Production, Transmission, Storage and Distribution), Transport (Mobile Sources), Carbon Dioxide from Biosphere, Non-Carbon Dioxide Gases from Biosphere, Livestock, Industrial Processes and Solvent and Other Product Use*, and *Waste*. The 1998 workbooks together with their supplements (also provided during the review) are referred to hereafter as workbooks. The S&A report and the subsequent responses were also used for this review.

## 4. General issues

### 4.1. Institutional arrangements

8. The Australian Greenhouse Office (AGO) is the agency responsible for the coordination of Australia's national GHG activities. The AGO and representatives of the Commonwealth, State, and Territory Governments, constituting the National Greenhouse Gas Inventory Committee (NGGIC), oversee inventory preparation. The AGO has developed quality assurance and quality control (QA/QC) procedures consistent with Good Practice Guidance for implementation.

9. Country-specific (CS) methodologies, which have been developed and approved as standardized Australian methodologies for sectoral emissions estimates, are described in the workbooks. The AGO requests that national consultants use these standardized methodologies as well as the UNFCCC reporting guidelines on annual inventories[5], hereinafter referred to as UNFCCC Guidelines and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* hereinafter referred to as the IPCC Guidelines. The consultants' output includes the

[5] Document FCCC/CP/1999/7, in particular the Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories (pages 3 to 79), and decision 3/CP.5 (page 115 to 116).

preparation of a detailed project report, completion of the sectoral CRF tables and the production of the sectoral contribution to the NIR.

10. The CS activity data (AD) and emission factors (EFs) for the preparation of the inventory are collected by national institutions including, among others: the Australian Bureau of Statistics (ABS), the Australian Bureau of Agriculture and Resource Economics (ABARE), the Bureau of Rural Science, State and Territory governments, State coal boards, the Department of Transport and Regional Services, the Electricity Supply Association of Australia (ESAA), the Australian Gas Association (AGA), and other industry associations. Broadly, the data and information sources encompass survey data on fuel and energy, electricity supply and generation, gas exploration and distribution, industry association data, fuel sales data, industry production data, population and employment data, forest harvesting and plantation inventories, and land clearing data.

11. To ensure the quality of the inventory, the AGO implements a system of external review and audit procedures, and coordinates the peer-review of the draft report. The report is distributed to an Interdepartmental Committee (IDC), comprising federal departments and agencies and to relevant State experts through the NGGIC for review. Following endorsement of the final draft by the NGGIC, the AGO seeks ministerial consent to submit the NIR and the CRF to the UNFCCC secretariat, and thereafter makes it publicly available. The IDC, NGGIC and other AGO sector experts conduct the independent assessment of the national inventory.

### 4.2. Record-keeping

12. The AGO inventory team maintains a file storage/network system of directories under the AGO local area network. The inventory directory contains all documents and files with intermediate and final results. Files with final results and associated materials are archived on CD-ROM.

### 4.3. Verification and QA/QC approaches

13. The responsibility for verification and QA/QC lies mainly with the AGO, which uses a system of internal and external review and audit procedures. The procedures include: technical reviews, accuracy checks on transcription of data and units, formulas and calculations, and the use of approved standardization procedures for emissions estimates. The AGO also has procedures for processing, documenting and archiving all the relevant NIR reports. Expert consultants are required to make “reality checks” which involve comparison of EFs with previous values and analysis of historical emissions trends for consistency. Where inconsistencies arise they must investigate and explain these values. The two largest national data sources, ABS and ABARE, perform QA/QC procedures on the primary AD at the source. These include both the bottom-up and top-down approaches to rationalize collected data. The level of voluntary survey participation by the private sector is decreasing due to privatization and increasing data confidentiality. The areas where the ERT noted that verification was less robust are discussed under the appropriate individual sectors.

14. In its 2000 inventory submission, Australia has implemented for the first time elements of QA/QC procedures consistent with the Good Practice Guidance. The reason for this early implementation of the guidance is that the country is taking a proactive approach toward using the inventory, not only for reporting purposes, but also as a planning and decision-making tool for

climate change policy making. The information on the QA/QC approaches was provided to the ERT during the visit. The ERT noted that a description of these approaches following the UNFCCC and Good Practice Guidance should be included in the future NIR.

### 4.4. Recalculations

15. In accordance with UNFCCC Guidelines, Australia included in its CRF and NIR information on recalculations covering the time series 1990 to 1997. The reasons for recalculations included changes in methods, AD and EFs. The ERT noted that estimation methods have been largely maintained from 1990-1998 in accordance with the published country workbooks and that new methods are documented when applied.

### 4.5. Transparency

16. The NIR and CRF contain the information required by the UNFCCC and IPCC guidelines which is necessary to ensure transparency of reporting. In addition, IPCC worksheets for emission estimates from various sectors were provided in a format compatible with the Australian methodology. The ERT noted that the inventory methodologies used have been documented in detail in the workbooks in line with the UNFCCC Guidelines. However, though the workbooks are referred to in the NIR, the information is not summarized as required by these guidelines. Australia acknowledged the need to provide summaries of these methods, including references to the differences from the IPCC methodology in the NIR. The use of indicators (e.g. NO, NE, included elsewhere (IE)) throughout the entire CRF contributed to transparency, although the ERT noted some misapplication of them in some tables.

### 4.6. Completeness

17. The ERT identified no major omissions in the NIR and CRF. In spite of unique national circumstances, the inventory has full geographic coverage of all sources and sinks, as well as all gases, included in the IPCC Guidelines for the entire 1990-1998 period. The inventory covered practically all the direct GHG emissions, by sources and removal by sinks, including $CO_2$, $CH_4$, $N_2O$, PFCs and $SF_6$. Estimates of the indirect GHGs, CO, $NO_x$, NMVOC as well $SO_x$ were also provided. The sources not reported in the inventory but included in the IPCC Guidelines have been summarized in the completeness table in the CRF. In particular, emissions of HFCs were not estimated and emissions from the consumption of $SF_6$ were estimated for one source only, i.e. magnesium foundries in the IP sector. Australia noted that processes to establish methodologies and data are underway and that estimates will be included as soon as possible.

### 4.7. Uncertainties

18. Uncertainties were estimated and reported in the NIR for all sources on a gas-by-gas basis. Uncertainties were estimated using a mix of qualitative and quantitative methods. Quantitative assessments were made using the IPCC approach and Monte Carlo analysis with probability distributions based on expert judgement as indicated in the Good Practice Guidance.

## 5. Previous reviews

### 5.1. Review of the second national communication

19. The substantive issues raised in the review of the second national communication included Australia's effort to report HFCs, $SF_6$, $SO_2$ and the indirect GHGs (NMVOC, NOx, and CO),

the adoption of the Australian financial year in national inventory reporting, and programmes aimed at reducing uncertainty and increasing confidence in the LUCF, particularly through the national land cover change project and the national carbon accounting system (NCAS).

20. The ERT noted that the NCAS project was launched in 1998 and work is in progress. The major AD sources are based on the financial year and this has not been changed. Australia's inventory experts point out that this approach provides a more robust estimate of emissions and in the long term the effect of the timing would not be significant. Regarding HFCs and $SF_6$ consumption, a new project has been initiated for a national survey and collection of AD. As such the emission estimates and reporting for the sector have been discontinued until completion of the project.

### 5.2. Synthesis and Assessment Report observations

21. The S&A report noted that implied emission factors (IEFs) from some energy, IP, and agriculture source categories were significantly different from IPCC default EFs and/or those of other Parties. Also, information for converting fuel combustion AD from gross calorific values to net was not provided. Other issues included the sharp drop in $CO_2$ emissions from the LUCF sector in 1991 and that emissions were not estimated for HFCs and $SF_6$, $N_2O$ from human waste and $N_2O$ emissions from ammonia production. Generally, the inventory experts gave adequate explanations for the issues raised in the S&A report. In particular, the differences in IEFs were due to the use of CS methodologies reflecting Australia's circumstances.

22. Specific comments on outstanding issues from previous reviews, if any, are noted below under the relevant sectors.

## 6. <u>Consistency with UNFCCC and IPCC guidelines</u>

23. Australia's NIR and CRF are broadly consistent with UNFCCC and IPCC guidelines. Australia used predominantly CS approaches, AD and EFs. While the ERT noted this effort as commendable, it encouraged AGO to employ IPCC methodologies in those few source categories where estimates were not provided due to the lack of CS methodologies and EFs. Specific instances where there is divergence from guidelines are noted below. When a reference to tier 1 or tier 2 methodology is made, this relates to the definitions of the Good Practice Guidance.

## 7. <u>Areas for further improvement</u>

***Identified by the ERT***

24. The ERT found that the Australian inventory was well reported and that the emissions were broadly well estimated. It noted the following issues for further improvement:

25. *Verification*: The ERT encourages Australia to consider implementation and reporting of a formal system of periodic verification for the whole national inventory, consistent with IPCC Guidelines and the Good Practice Guidance, and the use of academic and other experts not directly involved in the inventory preparation in an independent peer review as part of the QA/QC procedures. These will help to achieve an overall improvement in the quality of the national inventory.

26. *Methodologies, AD and EFs:* Australia is encouraged to consider using IPCC default or international EFs and AD where domestic values are not readily available. The ERT also notes that there is a need to study and review a few methods, and some AD and EFs that appear to be different from IPCC default values or values found in the literature. The following areas are recommended for review and the ERT suggests that these should be prioritized according to whether they are a key source or not, as recommended in the Good Practice report:

(a) Energy: conversion of gross calorific values (GCVs) to net calorific values (NCVs) particularly for those fuels with high moisture content, and updating of non-$CO_2$ EFs for mobile sources, petroleum products and fugitive emissions from coal.

(b) Industrial Processes (IP): comparative studies of the EFs of $CO_2$ sequestration by identified sink categories reported only in Australia, with other countries employing the same IP throughout the process, establishing a mechanism for reporting AD of synthetic gases that would encourage the ongoing collection of HFC, PFC, and $SF_6$ data, and separating and reporting $CO_2$ emissions from coke and coal use as reducing agents in IP to reflect the source of GHG emissions in the sector.

(c) LUCF: data collection methods in land clearing (forest and grassland conversion) for different years in the various States led to significant inconsistencies in the time series and resulted in very unreliable base year estimates for the sector; soil carbon might be insufficiently covered in the inventory, e.g. estimates of emissions from the liming of agricultural soils should be considered in the future; and for some forestry source categories AD collection methods should enable both emissions and removals to be identified in cases when both could occur.

(d) Waste: characterization of AD for $CH_4$ emissions by type of municipal solid waste (MSW) as recycling programmes significantly affect the percentage of degradable organic carbon (DOC) of waste generation, improvement of the $CH_4$ generation coefficient in the adapted United States regression model is different from the first order decay method (FOD) of IPCC, and characterization of wastewater to improve AD and EFs of $CH_4$ capture and generation.

27. Reporting: Australia should consider including summaries of methodologies in the NIR and also improving the use of indicators such as "NA", "NE", "NO", and "IE" in the CFR tables for consistency with the UNFCCC Guidelines. The ERT noted particularly the use of "0" /"NA" rather than "NE" for emissions by sources or removals by sinks not estimated but assumed to be insignificant or non-existing.[6]

28. *Confidentiality*: The ERT noted from presentations by ABARE, ABS and others that data availability is becoming increasingly difficult. This is attributed to, *inter alia*, privatization and market competition, which have resulted in decreased voluntary reporting of data by industry. The ERT therefore encourages Australia to consider developing approaches that will allow transparent reporting of emissions estimates while protecting confidential corporate data.

## 8. Planned and ongoing work by Australia

29. The ERT noted Australia's efforts in improving inventory quality. The ERT learned of current and future work to reduce uncertainties and improve transparency in critical sources and sink categories, particularly forest and grassland conversion. These include, *inter alia*:

[6] In particular, notation key "0"should be used according to the UNFCCC Guidelines for emissions by source and removals by sink of GHG, which are estimated, but are very small and would appear as zero after rounding.

(a) Atmospheric inversion studies by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to develop a spatially explicit emissions inventory for fire emissions and $N_2O$ from soils.

(b) Implementation of a major project initiative, the National Carbon Accounting System (NCAS), which would improve methods for estimating emissions by sources and removals by sinks in LUCF. The key components of the project for inventories are forest and grassland conversion information, and biomass and soil carbon estimation. The completed components are a soil properties map, land use and management information, and the state of knowledge of forest soils, which are published. The full carbon accounting model has been adapted to CS conditions. The model user-interface design is complete and is now being developed to enable “plot”, “estate” and spatial operation.

(c) The current review of the livestock and stationary energy combustion AD, emission factors and estimation methods.

### 9. Conclusion

30. The ERT considers that Australia has provided adequate information to the COP on its GHG inventory and GHG emissions trends and that in certain areas Australia can serve as a model for the inventory preparation of other countries. These areas include:

(a) Australia’s continuing investment in improving the quality of its data: in particular the NCAS for the LUCF sector and the enhancement of data on carbon capture in petrochemical feedstocks,
(b) Australia’s Greenhouse Challenge programme that encourages private sector collaboration with the Australian government, through the AGO, in providing data and facilitating reporting,
(c) Australia’s implementation of elements of “good practice” guidance, such as Monte Carlo methods for uncertainty analysis and country-specific data on key sources already for its 2000 inventory submission,
(d) Australia’s proactive approach toward using the inventory, not only for reporting purposes, but also as a planning and decision-making tool for climate change policy-making.

## B. ENERGY

### 1. General overview

31. Energy is the largest sector of the Australian GHG inventory. At the good practice level, eight of the 14 key sources identified at the national level are energy-related. They include: $CO_2$ from the stationary combustion of coal: 38 per cent, $CO_2$ from mobile combustion by road vehicles: 13 per cent, $CO_2$ from stationary combustion of natural gas: 9 per cent, $CO_2$ from the stationary combustion of oil: 6 per cent, fugitive emissions of $CH_4$ from coal mining and handling: 4 per cent, fugitive emissions of $CO_2$ from oil and gas operations: 1 per cent, $CH_4$ from oil and gas operations: 1 per cent, and $CO_2$ from mobile combustion in aircraft: 1 per cent.

32. In 1998 the energy sector contributed 75 per cent of national total GHGs, or 362,858 Gg. The emissions from fuel combustion were 331,344 Gg, representing about 68 per cent of the national total emissions and 91 per cent of the emissions from the energy sector. Energy

industries were the largest source of emissions from fuel combustion, accounting for 56.7 per cent of them, followed by transport, 22 per cent, manufacturing industries and construction, 15.6 per cent and other sectors making up for the rest. From 1990 to 1998 energy-related emissions grew by 21.1 per cent. Total $CO_2$ emissions from the fuel combustion subsector increased by 25 per cent as electricity generation increased by 10.3 per cent and coal combustion increased by 27 per cent, largely to meet that demand.

33. In 1998, fugitive emissions were 31,512 Gg, representing about 7 per cent of total national emissions and 9 per cent of energy emissions. Coal mining was the largest contributor to fugitive emissions, accounting for 59.3 per cent, followed by the oil and gas subsector, 40.7 per cent. $CH_4$ was the most important gas, which contributed 81.2 per cent of the fugitive emissions. Fugitive emissions grew 6.7 per cent from 1990 to 1998, and 10.1 per cent from 1997 to 1998 as a result of growth in emissions from coal production. However, emissions from the oil and gas sector declined by 4.2 per cent, due largely to technology improvements.

### 1.1. Verification and QA/QC approaches

34. AGO contracted two consulting firms, Energy Strategies Pty Ltd (ES) and George Wilkenfeld and Associates (GWA) to assist in the preparation of the energy sector inventories. GWA collected data for electricity generation and ES for other stationary combustion sources. The Victorian Environment Protection Authority compiled the emissions inventory for mobile combustion sources. In general, adequate approaches are in place to assure data verification (see report overview). There is little in the way of independent verification from outside entities as some of the data are confidential and are therefore difficult to review; other data may be more amenable to technical peer review. As electricity generators provide both AD and EFs, but no other fuel attributes, it is difficult to verify EFs. In addition, some companies report EFs that already contain oxidation factors. Following the IPCC Guidelines, Australia performed a comparison of the reference and sectoral approaches, which yielded a less than 1 per cent difference.

### 1.2. Completeness

35. All gases and sources from the energy sector are covered, with a few exceptions such as $CO_2$ emissions from coal mining, $CH_4$ from post-mining activities (surface mines), $CO_2$ from natural gas production and $CO_2$ and $CH_4$ from other leakage under the sub-category natural gas. Default IPCC methodologies are not available for estimating $CO_2$ emissions from these sources.

### 1.3. Transparency

36. The ERT noted that methodologies and assumptions for the energy sector are transparently presented in the workbooks, which are periodically updated. There are some minor issues relating to the updating of materials. National experts noted that these are areas they are working to address. More importantly, Australia uses GCVs for emission estimates from energy. The ERT noted that it was difficult to reconstruct the calculation using NCVs, especially for coals with high moisture content. Also, some of the oxidation factors for coal are embedded in the EFs as reported by electricity generators. It would be more transparent to have EFs and the oxidation factor for coal reported separately. For fugitive emissions, it was difficult for the ERT to trace the origin of some of the AD on oil and gas operations, which were based mostly on direct

measurement.

### 1.4. Uncertainties

37. Generally, quantitative methods employing Monte Carlo analysis have been applied in the uncertainty estimations where the reliability of the AD and EFs are high. Otherwise, qualitative expert judgement, based on IPCC Guidelines, is used. In some cases, a mixed approach has been utilized. Uncertainties from stationary combustion stem largely from EFs from energy industry where no independent data are available. On petroleum products, national experts noted large variations and uncertainty of the EFs for residual oil. Uncertainty for fugitive emissions estimates stems largely from poor EF. The specific estimates are provided under the respective sub-sectoral analysis.

### 1.5. Recalculations

38. The source categories, the specific gases, and the explanation for the recalculations are well documented in the NIR and in table 8(b) of the CRF. The overall result for the energy sector was a 1.2 per cent increase over the 1990 baseline. The basis of the recalculations included commissioning of a new power plant, more reliable EFs and/or AD for oil and gas, carbon sequestration in chemicals and ADO consumption in the transport sector. The others are adoption of a more accurate methodology for emissions from coke and blast furnace gases in iron and steel, and identification of a new source category, "distributed venting" in fugitive emissions. The adjustment in carbon sequestration in chemicals was 10 per cent lower than the 1997 NIR for all years including the 1990 baseline, and fugitive emissions from distributed venting appears very significant, contributing approximately 12.5 per cent of total $CO_2$ fugitive emissions. The ERT found the methodology changes to be broadly consistent with the IPCC Guidelines.

### 1.6. Consistency with UNFCCC and IPCC guidelines

39. *Emissions estimation, and the CRF and NIR:* The estimation of emissions and the presentation of information in the CRF and NIR generally follow the UNFCCC and IPCC Guidelines. In most cases, Australia uses CS methodologies and EFs. Two main differences from IPCC include consideration of a new source, "distributed venting", currently not covered by IPCC, and another source, "flaring at oil refineries", not well treated in the current IPCC Guidelines, according to Australian experts. The reporting of emissions from the later source in the CRF and the NIR is consistent with the UNFCCC Guidelines.

40. *Reference approach:* The sectoral approach and reference approach differed by less than 1 per cent. This small difference is based on such things as netting out of the energy content of sequestered carbon in the national approach, which is not included in the reference approach, national coal consumption data based on "actuals" and not one-year projections as in the reference approach, and slightly higher EFs for natural gas in the national approach.

41. *Feedstocks:* A new comprehensive methodology has been employed, using data from five chemical companies, which allows a more accurate assessment of carbon capture. The new methodology resulted in an estimate that was 10 per cent lower as compared to the previous inventory for baseline (1990) carbon capture. Due to a delayed response on the part of certain companies, there were a few omissions that the national experts acknowledged and which will be

added in subsequent inventories. The ERT was provided with detailed information on the data used for feedstock calculations.

42. The ERT noted that in its 1998 inventory, Australia has incorporated some of the Good Practice Guidance principles a year in advance of 2001 submissions when the application of these principles would be required. In particular, for most of the key sources Australia uses more elaborate approaches that rely on CS data, as compared to the IPCC default approach.

## 2. Key sources

### 2.1. Stationary combustion: $CO_2$ emissions from gas, oil, coal

43. In 1998 stationary combustion of fossil fuels contributed 53 per cent of total GHGs. The share of coal in this figure was 38 per cent, natural gas was 9 per cent and oil combustion 6 per cent. The largest contributor to stationary source emissions is electricity generation, which contributed 168,600 Gg, or 65.2 per cent of that category.

***Methodologies, activity data and emission factors***

44. Stationary combustion is divided into two primary categories: power plants and other stationary sources; separate methodologies were employed for each. For power plants, detailed bottom-up estimates are provided for each of the 43 major power stations, which are mainly coal-based. Both AD and $CO_2$ EFs were obtained from voluntary surveys of electricity generators conducted by GWA. Where EFs were not reported, either the previous year's data were used or, where they did not exist, IPCC defaults were used. ABARE Fuel and Electricity Survey (FES) data were used to fill in data gaps, and data were checked against ESAA industry surveys. For stationary sources other than electricity generation, the AD used is based on fuel type by economic sector and EFs are CS. The FES conducted biennially by ABARE is used to allocate top-down supply data to the appropriate sectors. For the iron and steel sector, emissions include both the energy component and the IP component of coking coal.

45. Emissions from smaller, off-grid power plants are estimated at more aggregated levels and accounted in category 1A1a, together with the large power stations. Emissions from generation at industrial sites are accounted for in the respective sectors for these industries. For non-$CO_2$ emissions, EFs for fuel and equipment type combinations were obtained from the United States Environmental Protection Agency (USEPA). For each economic sector, the factors are weighted by the fuel and equipment mix in the sector, to obtain weighted average EFs for each fuel used in the sector. These technology-weighted EFs have been updated three times since 1990 with the most recent being 1997.

46. For petroleum products, EFs are based on Department of Industry Science and Resources (DISR) values that have been used without any changes since the inventory was first produced but for which the original documentation is no longer available. For natural gas the EFs are based on data published by AGA that are updated annually based on the heat content of the gas in each pipeline. There are some minor discrepancies in EFs such as the inclusion of coke oven gas as a solid rather than gaseous fuel (yielding an unusual IEF) and a value for liquid fuel used in food processing which is outside the expected range for EFs.

***Uncertainties***

47. For stationary combustion, uncertainties are estimated by the Monte Carlo method for electricity generation as ± 1.6 per cent for $CO_2$ and ± 12.4 for $N_2O$. Expert judgement for the other energy industries yields ± 3.6 per cent for $CO_2$, ± 20 for $CH_4$ and ±40 for $N_2O$. For the remaining categories of stationary combustion, $CO_2$, uncertainties are broadly the same as for energy industries, while for non-$CO_2$ the estimated uncertainties are much higher. The uncertainties stem largely from EFs that come directly from industry and where no independent analysis is available. On petroleum products, the host country experts noted large variations and uncertainty of the EFs for residual oil.

## 2.2. Mobile combustion: $CO_2$ emissions from road vehicles

48. Mobile combustion, principally of petroleum in road vehicles, contributes 13 per cent to total national emissions. Emissions from this source increased by 18 per cent between 1990 and 1998.

### *Methodologies, activity data and emission factors*

49. Australia uses a methodology that allows it to estimate emissions by different vehicle and engine types, fuel used, fleet age distribution and emission control technologies. An approach consistent with IPCC tier 2 is used for aircraft, and for the rest of the mobile sources tier 1 and tier 2 approaches are used for $CO_2$ and non-$CO_2$ emission estimates respectively. EFs are CS for $CO_2$, while IPCC defaults are used for non-$CO_2$ emissions, with the CS factors detailed in Transport Workbook 3.1. $CH_4$ exhaust fractions for sources other than passenger vehicles were estimated from USEPA data. Vehicle-kilometres-travelled are obtained for the ABS Survey of Motor Vehicle Use. Landing and take-off cycles are obtained from aviation statistics.

### *Uncertainties*

50. For mobile sources, expert judgment based on IPCC Guidelines was used for the overall transport category. This yielded ±3 per cent for $CO_2$, ±21 per cent for $CH_4$ and ±55 per cent for $N_2O$. Monte Carlo approaches were used for some disaggregate categories - passenger cars and heavy trucks. The *Mobile Sources Report* provided probability density functions for the Monte Carlo analysis.

## 2.3. Fugitive emissions

### *Fugitive emissions from solid fuels*

*Methodologies, activity data and emission factors*

51. Methodology consistent with an IPCC tier 2 approach was used to estimate fugitive emissions from coal mines. The workbooks describe this methodology well. EFs are derived from regression analysis of field measurements. Information on coal production by mine is collected and reported to State government agencies on an annual basis. There are two main sources of AD: the New South Wales Coal Industry Profile (Department of Mines and Resources) and Queensland Department of Mines and Energy.

52. CS-EFs differ from the IPCC default EFs as follows:

(a) For underground mines (mining activities) Australia reported IEF = 7.66 (IPCC = 10-25). According to the methodology used and expert estimates, the conversion factor used equals 0.616 kg$CH_4$/m3, which does not correspond to the IPCC Guidelines default (0.67) and Williams (1996) – 0.65. It leads to a conservative value for the EF.

(b) For underground mines (post-mining activities) Australia reported IEF =0.39 which is lower than IPCC (0.9 – 4.0). The explanation given to the expert review team (ERT) was that the IEF is a result of measurement.

(c) For surface mines (mining activities) the measured CS-IEF is within the IPCC range.

(d) For surface mines (post-mining activities), Australia did not report IEF and used the notation key “NA”. Australia did not estimate emissions from this sub-category, assuming that such emissions do not exist or are very small. The ERT noted that this assumption needs to be verified given that the IPCC Guidelines give the range of emission factors from 0 to 0.2.

***Fugitive emissions from oil and gas***

*Methodologies, activity data and emission factors*

53. A CS methodology is used, which corresponds to IPCC tier 3. The methodology is well documented in Workbook 2.1. CS-EFs differ from IPCC defaults. The ERT was informed that the IEFs reported in the NIR are a result of aggregation of national level AD and emissions estimates reported by different companies. Fugitive emissions from oil and gas are based on direct measurement (annual survey), provided by oil and gas industries. Information on oil and gas production, transmission and distribution is collected and reported to State government agencies on an annual basis. There are two main sources of AD: the Australian Petroleum Production, Exploration Association report for oil emission data and the AGA.

*Uncertainties*

54. For fugitive emissions the Monte Carlo method was employed using expert judgement to derive the density functions. For fugitive emissions the NIR provides qualitative estimates of uncertainty. The uncertainty for $CH_4$ estimates from coal mines is ±12 per cent, for oil and gas $CO_2$ ±20 per cent, and for $CH_4$ from the oil and gas sectors ±30 per cent. Uncertainty for fugitive emissions estimates stems largely from poor EFs.

### 2.4. Non-key sources

55. The greatest uncertainty lies in emissions of $CH_4$ from residential burning of wood. The AD is uncertain because much of the wood is collected by individuals for use in residential fireplaces and does not enter the data collection stream. Since the fuel data can not be measured, the estimation method is based on the number of fireplaces. In addition, in the case of other uses of biomass, e.g. bagasse and fuel wood, it remains unclear whether the reported quantities refer to dry or wet matter. National experts acknowledge that assessing emissions from biomass is a difficult area, as it is for most countries, and that further research is needed.

### 2.5. Bunkers

56. In 1998, international bunker fuels generated 9,473 Gg of emissions. The split between domestic and international bunkers is obtained by ABARE from the DISR publication *Petroleum Statistics*. The data are collected from oil refiners and petroleum companies who

report via a monthly survey on domestic (coastal) versus international bunkers.

## 3. Areas for further improvement

### 3.1. Identified by the Party

57. The following work is planned or ongoing:

(a) For mobile sources Australia is seeking to use revised ABS data from the Survey of Motor Vehicle Use, and new methods to reflect changes in regulations, technology and data.

(b) For electricity, Australia is proposing a review of data collection and analysis within power stations. Such analysis could aid quantitative uncertainty estimates.

(c) An expert review of the AD and methodologies for the stationary combustion source categories has commenced.

(d) Australia proposes developing EFs for secondary fuel such as biomass co-fired with coal.

(e) Regarding carbon storage in feedstocks, as 1998 was the first year of a new method involving company-specific responses, the next inventory will feature improved coverage.

### 3.2. Identified by the ERT

58. The following suggestions were made by the ERT:

(a) Independent peer review of coal EFs by academic and other experts not involved in inventory preparation could help to verify data for this important category.

(b) Separate reporting of coal oxidation factors would allow more transparency.

(c) Cross-checks with continuous emissions monitoring at available sites, especially at large-scale electricity facilities could be a useful tool in the validation process.

(d) Information for converting gross calorific values to net calorific values would be helpful, especially for those fuels where that transformation would differ from IPCC assumptions. The national experts agreed that this would add to the transparency of inventory calculations.

(e) For mobile sources, Australia may wish to update the currently used IPCC EFs for non-$CO_2$ gases to reflect the CS conditions better.

(f) A restructuring of the Workbook on Transport may aid in transparency of the calculation of fleet age and related characteristics.

(g) Reviewing, updating and fully documenting petroleum product EFs and non-$CO_2$ EFs from coal would contribute to improvements in the quality of emission estimates from fuel combustion. It should also assist in self-validation and transparency of the estimates.

(h) Australia is encouraged to improve further the EF for fugitive emissions from the coal sector and the quality of AD on the coal, oil and gas industries, including: improving $CH_4$ and $CO_2$ data at gassy underground mines, improving field measurements of $CH_4$ at open cut mines and improving the data quality on losses from gas distribution.

## C. INDUSTRIAL PROCESSES

### 1. General overview

59. The IP sector was identified as a non-key source. IP net emissions were 9,830 Gg in 1998 and contributed 2.2 per cent to total national emissions. Mineral and metal production are the main source categories, accounting for 1.2 per cent and 0.8 per cent respectively. $CO_2$ is the predominant gas, accounting for 80 per cent of the sector's emissions (2.3 per cent of national totals).

60. Net $CO_2$ emissions are unique to Australia because a total of –122Gg $CO_2$ removals by sinks have been reported for aluminium production (–52 Gg) and soda ash production (-70 Gg). Further, the sectoral emissions do not include $CO_2$ emissions from the use of coal/coke as a reducing agent in the iron and steel subsector, which was reported under fuel combustion in the energy sector. The two factors account for the apparent low contribution of this sector to total national emissions.

61. Emissions from IP declined continuously between 1990 and 1995, due mainly to the reduction in PFC emissions from aluminum smelting attributed to technological improvements in the production process. This resulted in an overall sectoral emissions reduction of 18.4 per cent in 1998 relative to 1990. However, from 1997 to 1998 an increase in emissions was recorded as a result of growth in the production of aluminum, cement clinker and lime.

#### 1.1. Verification and QA/QC approaches

62. The AGO contracted Burnbank Consulting to prepare the IP sector inventory. The ERT learned that the inventory expert performs crosschecks of AD and EFs by comparing plant-level data and data reported by national institutions and industry associations with historical data to ensure reasonableness. Where necessary, the consultant followed up and resolved inconsistencies and performed recalculations. Other verification procedures followed by statistical agencies and the AGO are outlined in the general overview of this report.

#### 1.2. Completeness

63. The CRF tables were completed for the 1990-1998 period. Emissions of $CO_2$ were reported for most sources in mineral products and metal production except road paving. $CO_2$, $CH_4$, and $N_2O$ emissions from significant chemical industry sources, namely ammonia production, carbide use, food and drink (table 9) are not estimated due to lack of data and/or methodology. Similarly, potential and actual emissions from consumption of HFCs and PFCs and sulphur hexaflouride ($SF_6$) are not estimated. According to the national experts, the IP inventory at present covers around 80 per cent of identifiable and significant sources in the sector. The other gases reported and the corresponding sectors are $SO_2$ (from aluminium production and road paving), non-methane volatile organic compounds (NMVOC) (from road paving and food and drink production). Estimates of $NO_x$, and CO were not reported for any sector. The ERT

proposed inserting "IE" in $CO_2$ emissions for the iron and steel sector in CRF table 9, given its inclusion in the energy sector.

### 1.3. Transparency

64. The methodologies and assumptions for the IP sector are detailed in the workbooks. The ERT noted that not all explanations of methods used in the IP inventory are transparent. Methodologies to estimate $CO_2$ removals by sink in aluminium processing by the Bayer Process, which is not included in the IPCC Guidelines, and soda ash production by the Solvay Process, at present referred to in the IPCC Guidelines, constitute higher tier methods. These would require detailed country research and documentation of EFs to increase their transparency.

### 1.4. Confidentiality

65. The ERT learned that there is increasing difficulty in obtaining and verifying data at the plant level due to confidentiality. A case in point is the discontinuation of $CH_4$ emissions reporting from the chemical industry subsector due to plastic production data by polymer no longer being published by the ABS. Data have been sought directly from industry but a complete time series has not yet been obtained. The AGO, however, indicated a positive trend in industry's willingness to report AD and EFs directly to them under its Greenhouse Challenge programme. This development is moving data reporting from the public domain to the AGO, which should provide adequate data for the IP inventory.

### 1.5. Uncertainties

66. Three different approaches for the estimation of uncertainties were used for the large sources. They were Monte Carlo, Latin Hypercube and expert judgement based on the recommended IPCC methodology. The results of the three methods were consistent. The highest estimates for $CO_2$ were cement clinker (+/-7), lime (+/-14.8) and aluminium (+/-4.9). The NIR gives an overall uncertainty for $CO_2$ emissions from IP as +/-4.5 per cent using the IPCC approach. $CH_4$ and $N_2O$ showed very high uncertainties, greater than 60 per cent. The IEF of $CH_4$ from iron and steel is judged to be highly uncertain and needs further work to improve it.

### 1.6. Recalculations

67. Recalculations were performed for three subsectors for the period 1990-1997 due to: improved EFs derived from more reliable plant-level AD for PFC emissions from aluminium production, removal of $CH_4$ emissions estimates from the chemical industry (plastic production) for the period 1990-1997 due to discontinuation of data reporting from the industry, and withdrawal of $SF_6$ consumption estimates for electricity transmission and distribution equipment because the methodology, based on applying US per capita values to Australia, was considered inappropriate. The AGO has begun consultations with the electricity supply and transmission industry to obtain actual consumption data. In terms of $CO_2$ equivalent, the recalculations resulted in removal of the previously reported figures of 6.2 Gg in 1996 and 1,768 Gg in 1997. The ongoing project on the $SF_6$ inventory will provide AD needed for the relevant emission estimates.

### 1.7. Consistency with UNFCCC and IPCC guidelines

68. The estimates and reports of emissions in the CRF and NIR are broadly consistent with the IPCC Guidelines and the UNFCCC reporting guidelines. The two main differences from the

IPCC Guidelines are the reported $CO_2$ removals by sinks identified in soda ash production and the integrated aluminium industry of the mineral and metals subsectors respectively The ERT noted that these $CO_2$ removals should have been reported in the documentation box of tables 2(I).A-Gs1 and 2(I).A-Gs2, together with a clear explanation of the sequestration process. This explanation would highlight the uniqueness of these sinks to Australia and provide a reason for the apparent low emissions from aluminium and soda ash production reported in the summary table 1.A.

## 2. Non-key sources

69. There are no key source categories in industrial processes (IP). Significant IP source categories include cement and lime in the mineral subsector, and aluminium and iron and steel in the metals subsector. The Australian IP inventory team used CS methodology and CS AD and EFs, which are generally consistent with the tier 2 methods. The methods are well documented in Workbook 7.1. AD is obtained mainly from production and consumption statistics, published sources, industry organizations and companies. The consistency of the Australian methodologies, AD and EFs with Good Practice Guidance is discussed below.

### 2.1. Cement production

70. A CS method and EF is used for the $CO_2$ emissions calculation for cement production. The method is consistent with the tier 2 approach. The EF is derived using a 0.66 CaO fraction in clinker (IPCC default =0.65). The method assumes that the non-carbonate content of clinker is negligible, but does not consider cement kiln dust losses that are estimated to have a potential of reducing the $CO_2$ emissions maximum by about 5 per cent according to the Good Practice Guidance. The ERT notes that Australia should be encouraged to discuss the estimation of the cement kiln dust factor with the industry when applying Good Practice Guidance in future inventories.

71. $SO_2$ emissions are assumed to be negligible and are therefore not estimated. The ERT, however, noted that the ore analysis should be verified and cross-checked with the industry since other OECD countries which are using pollution control equipment are still reporting some levels of $SO_2$ emissions.

### 2.2 Lime production

72. The methodology used is consistent with the tier 2 approach. The method considers lime production from three sources of ore with varying lime content in the product, as compared with the Good Practice Guidance default, as indicated in the table below.

| Lime type | Stoichiometric ratio (1) | | Lime content in product (2) | | Emission factor (1) x (2) | |
|---|---|---|---|---|---|---|
| | Australia | IPCC | Australia | IPCC | Australia | IPCC |
| High-calcium (A) - CaO | 0.785 | - | 0.86 | - | 0.68 | - |
| High-calcium (B) - CaO | 0.785 | 0.79 | 0.90 | 0.95 | 0.71 | 0.75 |
| Dolomite - CaO.MgO | 0.913 | 0.91 | 0.95 | 0.95/0.85 | 0.86 | 0.86/0.67 |
| Hydraulic lime - CaO | - | 0.79 | - | 0.75 | | 0.59 |

Sources: IPCC Good Practice Guidance and Australia - country methodology Workbook 7.1.

73. The IEF is an aggregate of three types of lime, and therefore depends on the proportion of each lime type in any year's production. The wide difference between CS EFs and the IPCC default reported in the draft tables of FCCC/WEB/2001/1 is that the latter uses stoichiometric ratios. The ERT noted an 8 per cent error in the EF for dolomitic lime in the 1998 NIR

(page B108). The value used is 0.785 instead of 0.913 x 0.95 (0.86), which has been used for previous years' estimates. This issue will be investigated by the Australian IP inventory team.

### 2.3. Soda ash production and use

74. The $CO_2$ sequestration estimated in soda ash production inventory methodology represents a rather unique approach. The IPCC Guidelines make a reference to this approach as a natural process and also as a temporary sink. The reported estimate of 0.23 tonnes of $CO_2$ per ton of soda ash sequestrated by calcium chloride wastewater discharge to the ocean from soda ash production employing the Solvay process is based on experimental data published in 1995.

75. Australia is encouraged to validate the sequestration factor in this subsector in order to reduce the uncertainty and improve the transparency of the reporting.

### 2.4. Iron and steel production

76. The methodology for emission estimates from iron and steel production is consistent with the tier 2 approach. To avoid double counting, $CO_2$ emissions from the use of metallurgical coke as a reducing agent are reported in the energy sector. The ERT noted that this alternative reporting of $CO_2$ emissions, while in line with the flexibility of the IPCC Guidelines and good practice, makes the IP sector emissions contribution appear low for the level of industrial activity in the country. The ERT therefore suggests that Australia should endeavour to separate and report $CO_2$ emissions from coal and coke consumption in the iron and steel industry under the respective sectors. In such a case, the inventory experts would have to perform a double counting/completeness check to reduce the potential risk.

77. On the current reporting, the ERT reached a consensus with national experts to change "NA" in CRF for iron and steel to "IE" since the $CO_2$ emissions have been reported elsewhere.

### 2.5. Aluminium production

78. Aluminium production contributed 0.8 per cent of national totals from $CO_2$ emissions from anode consumption, PFC emissions from electrolytic cell (pot) operation and $CO_2$ sequestration from alumina from Bayer liquors. The Bayer liquor and the PFC methods are discussed as follows.

79. *$CO_2$ sequestration in Bayer liquors*: A CS methodology, unique to Australia, has been developed for $CO_2$ emissions from the integrated aluminium industries, which includes downstream aluminium production. It considers calcium carbonate precipitated in Bayer liquors of aluminium processing as a sink category. The subsector emissions are therefore reported as net emissions. The $CO_2$ sequestration factor was provided by the aluminium industry. The estimated sequestration of (–52Gg) accounts for the apparently low IEF for aluminium production. The ERT provided references for other plants which have studied these phenomena; Australia could contact these plants in order to compare sequestration factors with the aim of increasing the transparency of the CS values adopted.

80. *PFC emissions from aluminium production*: A CS methodology was also used to estimate figures for PFC emissions from aluminium production provided by industry. Two

separate methods have been used, based on the two technologies applied in Australia, namely the Pechiney overvoltage method (Pechiney technology) and the Slope method (Alcoa). The IEF reported is a production weighted average of the EFs for the two methods. The sharp drop in the PFC emissions is due to improved technology for control of anode effect frequency and duration, and overvoltage in both technologies.

### 3. Previous reviews

81. The key issues raised in the S&A report are the low $CO_2$ IEFs for lime production, reporting of soda ash as a sink, and no estimation of iron and steel production and $N_2O$ emissions from ammonia. The ERT verified Australia's response that purity factors for lime production were used, and that $CO_2$ from iron and steel was reported under the energy sector. These were consistent with the IPCC Guidelines and the Good Practice Guidance. Regarding the lack of AD for ammonia, the ERT suggested that Australia use the data published in the 1998 *UN Industrial Commodity Statistics Yearbook* in the absence of country data. Australia will seek to verify the source of data in this publication.

### 4. Areas for further improvement

#### 4.1. Identified by the Party

82. The major planned improvement presented to the ERT includes a project on data collection of HFCs and PFCs consumption, as well as on $SF_6$ use in the electrical transmission and supply industries, which would be completed by the end of 2001 and 2002 respectively. Australia is also seeking better AD and EFs for nitric acid production, limestone and dolomite use, and in-house production of lime.

#### 4.2. Identified by the ERT

83. The IP sector was identified as a non-key source. However, it could become a key source due to increasing consumption of HFCs and PFCs as substitutes for ozone depleting substances and if the process $CO_2$ emissions from coke and coal used as reducing agents in iron and steel are accounted for in this sector. The ERT suggested, therefore, that the later emissions be reported in IP to reflect the importance of this sector in the Australian economy in terms of its emissions.

84. Australia is encouraged to develop measures which would encourage data reporting from the chemical industries which have currently stopped disclosure of data due to confidentiality.

85. Further research is needed into $CO_2$ sequestration by calcium chloride discharged to the ocean during the Solvay process for soda ash production. Comparison of $CO_2$-sequestration in aluminium production with other countries' rates of sequestration is also necessary to verify the current $CO_2$ absorption coefficient adopted by Australia.

86. International data and IPCC default methodology could be used where applicable in the absence of in-country data.

## D. AGRICULTURE

### 1. General overview

87. The agriculture (AG) sector is the largest source of $CH_4$ and $N_2O$ in the Australian inventory and it contributed approximately 29 per cent of total national emissions in 1998. Five sources in the AG sector are considered key under the Good Practice Guidance, namely $CH_4$

from enteric fermentation, direct $N_2O$ emissions from agricultural soils, $CH_4$ and $N_2O$ from savanna burning, and $N_2O$ emissions from agricultural soils animal production.

## 1.1. Verification and QA/QC approaches

88. The ABS supplies agricultural data and statistics to the AGO. Documentation of the QA/QC approaches used by organizations other than the ABS is not always readily available. The AGO carries out QA/QC on the inventory worksheets for the entire sector. ABS QA/QC approaches include: frame checks, survey design, intensive follow-up, input edits, significance editing (including analysis of outliers) and output editing (including historical comparisons and comparisons with other sources). The agricultural census and surveys have statutory backing.

## 1.2. Completeness

89. The CRF reports emission estimates of $CH_4$ and $N_2O$ from all relevant source categories. $NO_x$, CO and NMVOCs were also estimated from both prescribed burning of savannas and field burning of agricultural residues, for 1990 to 1998. $CH_4$ emissions from manure management are reported as 0, from all animal classes except dairy and feedlot cattle, pigs and poultry. $CH_4$ emissions from agricultural soils are reported as NE, and direct soil emissions from N-fixing crops and crop residues, and indirect emissions of $N_2O$ from agricultural soils are reported as NE.

## 1.3. Transparency

90. See the discussion of transparency in the overview section of this report.

## 1.4. Uncertainties

91. The CRF provides qualitative estimates of uncertainty. Australia does however, undertake extensive statistical analysis; this is described and quantitative estimates of uncertainty are tabulated within the NIR for each component of the AG sector inventory (the livestock subsector and the non-$CO_2$ emissions from the biosphere “subsector” are considered separately).

## 1.5. Recalculations

92. Recalculations of emissions for the AG sector are documented in the CRF and NIR, including: enteric fermentation, manure management and AG residue burning. CRF table 8(b) gives the reasons for the recalculations except for subsector 4F (AG residue burning). The national experts agreed that this was an oversight, as explanatory text is provided in the NIR.

## 1.6. Consistency with UNFCCC and IPCC guidelines

93. Australia has developed its own methodology using CS methods and EFs in many areas, with some IPCC default values for minor subsectors. Consistent with the UNFCCC Guidelines, the NIR also provides AD and calculation worksheets based on the IPCC Guidelines. Consistent with the IPCC Guidelines, AG sector emissions are reported as three-year averages.

### 1.7. Activity data

94. ABS conducts AG surveys annually and a census periodically. Data are collected on pastures, broadacre crops (all major crops in each State), horticulture, livestock numbers and some demographics - eggs, ewes mated, sheep shorn/wool produced. Other data come from the Australian Lot Feeders Association, Meat and Livestock Australia, the Australian Dairy Corporation and Wool International, the Australian Ricegrowers Cooperative, the Fertiliser Industry Federation of Australia, the State Forestry, National Parks and Fire services, and the Australian Canegrowers' Association. Data are collected on a regional and State basis.

## 2. Key sources

### 2.1. $CH_4$ from enteric fermentation

***Trends***

95. Enteric $CH_4$ emissions contributed 12.5 per cent to the total national emissions in 1998. Enteric emissions have declined by almost 6 per cent since 1990. A decline in sheep numbers (by 29 per cent) as a result of an economic downturn in wool production, has contributed to this decline, but has been partially offset by increases in beef cattle (by 6 per cent) and dairy cattle (by 18 per cent). In 1998, non-dairy cattle, sheep and dairy cattle made up 8 per cent, 3 per cent and 1 per cent of total national emissions respectively. All other animal classes combined contributed less than 1 per cent.

***Methodologies, activity data and emission factors***

96. A tier 2 approach is used for cattle, sheep and pigs, and a tier 1 approach for other livestock classes. The CS tier 2 methodology for enteric fermentation reflects national circumstances and is designed to be consistent with the IPCC Guidelines. The ERT was provided with documentation (Workbook 6.1; Howden, 2000) that further describes the Australian approach and identifies differences between the Australian approach and the IPCC methodology. AD for all animal classes are provided in an appendix as part of the NIR. This information is further subdivided by state, age and milk production (dairy cattle). Further detail is also provided on feedlot cattle.

97. A mix of CS and IPCC default EFs are used. CS EFs are used for dairy cattle, non-dairy cattle, sheep and pigs, and IPCC default values for buffalo, camels, horses and mules. The IPCC does not provide default values for deer, alpacas, and ostriches/emus. A CS EF for deer was adopted from the literature and EFs for alpacas and ostriches/emus were estimated by the Australian Livestock Working Group, based on animal size and anatomy, to be equivalent to EFs for donkeys and goats respectively.

***Uncertainty***

98. The NIR gives an uncertainty for $CH_4$ from enteric fermentation as +2 to +23 (95 per cent range).

***Previous reviews***

99. The issues raised in the S&A report under this source category were:

(a) $CH_4$ IEFs for dairy and non-dairy cattle in 1998 seem higher when compared to the IPCC default EF for the region of Oceania and also relatively high compared to other Parties, while those of dairy cattle increased by 4 per cent from 1990 – 1998.

(b) There were high annual percentage changes in emissions, AD and IEFs for some livestock types for which AD in general was relatively small (buffalo, camels and lamas, deer, goats, horses, mules and asses, ostriches/emus, other).

100. Consistent with Australia's response, the ERT learned that CS IEFs are aggregate EFs constructed from AD segregated by state and season, and they use a number of parameters (e.g. liveweight, liveweight gain, milk production, dry matter digestibility and feed intake) as appropriate, combined in a series of algorithms to produce a national $CH_4$ emissions total for each animal class. The national total emissions for each animal class are used to derive the aggregate EF. This approach means that the aggregate EF can show changes across the time series as it will reflect productivity and other herd/flock changes. For dairy cattle the $CH_4$ EF increases by 4 per cent from 1990 to 1998 as average milk production has increased by about 30 per cent since 1990.

### 2.2. Direct $N_2O$ emissions from agricultural soils

***Trends***

101. Direct $N_2O$ emissions from agricultural soils contributed 3 per cent of the total national emissions in 1998. These emissions have increased by 20 per cent from 1990 to 1998 as a result of increased fertilizer use, which contributed 26 per cent to the total direct $N_2O$ emissions from agricultural soils in 1990, and 42 per cent in 1998. A small decrease (8 per cent) in $N_2O$ emissions from disturbed soils[7] occurs across the time period.

***Methodologies, activity data and emission factors***

102. The methodology used by Australia differs significantly from the IPCC methodology. The total for direct emissions of $N_2O$ from agricultural soils covers direct emissions from synthetic fertilizers, animal wastes and emissions from disturbed soils. Documentation was provided further describing the Australian approach and noting differences between it and the IPCC methodology. AD for the subsectors contributing to direct $N_2O$ emissions from agricultural soils are provided in an appendix to the NIR. Further documentation was provided to the ERT giving the specific sources of the AD (CSIRO 2000).

103. In line with the CS methodology described for $N_2O$ emissions from disturbed soils, EFs have been developed for this subsector based on Australian measurements of natural systems, croplands and pasture. The IPCC default EF for artificial fertilizer is used, and the EF for animal wastes applied to soil has been derived from the published literature. These EFs are recorded in an appendix to the NIR, but their sources are not referenced.

***Uncertainty***

104. The NIR gives an uncertainty for direct $N_2O$ emissions from agricultural soils as ±64 (95 per cent range).

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7 The direct $N_2O$ emissions from disturbed soils are recorded in the CRF under cultivation of histosols.

***Previous reviews***

105. The S&A report noted that the $N_2O$ IEF for 1998 for cultivation of histosols is lower by a factor of 10 compared to IPCC defaults and to other Parties. In its response, Australia has explained the sources of these differences, which are based largely on the country's circumstances. In particular, the CS method is used to estimate $N_2O$ emissions from disturbed soils, which includes emissions from N-fixing crops and crop residues, cultivation of organic soils, and atmospheric nitrogen deposition (CSIRO, 2000). The IPCC CRF do not provide specific categories for $N_2O$ emissions from disturbed soils and in the CRF for Australia they are recorded under cultivation of histosols.

### 2.3. $CH_4$ and $N_2O$ from savanna burning

***Trends***

106. $CH_4$ and $N_2O$ emissions from savanna burning each contributed 1 per cent to total emissions in 1998 and both were 34 per cent higher in 1998 than in 1990. The NIR notes that the large increase observed in this sector between 1997 and 1998 (13 per cent) was the result of severe and extensive fires resulting from the 1997 El Niño event.

***Methodologies, activity data and emission factors***

107. Australia applies a CS methodology, which approximates the algorithm used in the IPCC Guidelines. This methodology is described in Workbook 5.1; it uses information on fuel loads, burning efficiency and composition of grassland and savanna. No stratification of fuels into live and dead material is done, as in Northern Australia all fires occur during the dry season when the fuel is senescent grass and tree litter. The annual areas burnt are averaged over 10 years.

108. EFs are derived from Australian measurements referenced in Workbook 5.1. AD for prescribed burning of savannas are provided in an NIR appendix and are disaggregated by State. Further documentation was provided to the ERT giving the specific sources of the AD (CSIRO 2000).

***Uncertainty***

109. The NIR notes that the AD for this sector are highly uncertain as they are collated from a large number of State government organizations with a wide range of data quality protocols. The NIR gives an uncertainty for $CH_4$ and $N_2O$ from savanna burning as –63 to +106 and –67 to +102 respectively (95 per cent range). The ERT learnt that the main source of uncertainty is the fuel load.

***Previous reviews***

110. Under $CH_4$ and $N_2O$ emissions from prescribed burning of savannas, the S&A report noted that the ecological zones (States and Territories for Australia) were entered in different orders for different years, notably for 1998. The transcription error was subsequently identified and corrected. The report also raised the issue of the 13 per cent change in non-$CO_2$ emissions between 1997 and 1998, which was attributed to fires during the 1997 El Niño event and recorded in the NIR, page A-25.

### 2.4. Agricultural soils: animal production

***Trends***

111. $N_2O$ emissions from agricultural soils/animal production contributed 1 per cent to total emissions in 1998. These emissions have decreased by 9 per cent from 1990 to 1998 as a result of decreases in animal numbers, in particular sheep.

***Methodologies, activity data and emission factors***

112. The methodology used is documented in Workbook 5.1 and 6.1, and is further explained in other material made available to the ERT (CSIRO, 2000). EFs for urine applied to pasture is derived from Australian and New Zealand measurements on permanent improved pasture. AD for $N_2O$ emissions from agricultural soils (animal production) is provided in appendix table 4 as part of the NIR. Further documentation was provided to the ERT giving specific AD sources (CSIRO 2000).

***Uncertainty***

113. The NIR gives an uncertainty for $N_2O$ from this subsector as –66 to +99 respectively (95 per cent range). High uncertainty in EFs is the main source of this uncertainty.

***Previous reviews***

114. The S&A report noted that the $N_2O$ IEF for 1998 animal production is the lowest (0.0043 kg $N_2O$-N/kg N) of the reporting Parties (median value: 0.02). Further, the reported activity data for animal production in 1998 (N excretion on pasture range and paddock) is 2.4 per cent higher than the total N excretion for pasture range and paddock reported in table 4B(b). The Australian methodology differs from the IPCC methodology in that it uses a mass balance approach in which total N output is split into urinary and faecal components. The Australian categories of emissions from animal urine and faecal deposition correspond to the IPCC category "pasture, range and paddock".

### 2.5. Non-key sources

115. Australia does not estimate indirect $N_2O$ emissions from agricultural soils resulting from nitrogen leaching and subsequent denitrification in estuaries and waterways. An explanation for this approach is touched on in Workbook 5.1 (1996 supplement), is further documented in material given to the ERT (CSIRO 2000) and was also explained to the ERT by the national experts. Limited evidence indicates that Australia is significantly different from other continents in that it is very dry; Australian soils tend to be N limited and the N output of the major catchment area is <$100^{th}$ of European/USA levels. Because of these factors, Australia has chosen not to report indirect $N_2O$ emissions, because in its view, the IPCC default values (even though the IPCC offers a range of EFs for different climate zones) would give estimates that were extremely uncertain, and such estimates would increase the overall uncertainty of the Australian inventory.

### 3. Areas for further improvement

#### 3.1. Identified by the Party

116. An expert review of livestock methods/data has begun in order to improve methodology and data sources, to quantify uncertainty further, to document differences from the IPCC Guidelines adequately, and to identify (and prioritize) gaps in data and systems knowledge. In other parts of the AG sector, continuing improvements to fire area data by continuing fire scar analysis, and development of spatially explicit emissions inventories of GHGs are under way. Research under way at CSIRO is relevant to potential improvements to estimates of $N_2O$ emissions.

#### 3.2. Identified by the ERT

117. The better use of notations (NA, NE, IE), and the use of category "Other" for reporting emissions from soil disturbance, together with the corresponding use of the documentation box for table 4D in the CRF, would aid transparency in reporting emissions from agricultural soils. In addition, the ERT encourages Australia to estimate indirect emissions of $N_2O$ from agricultural soils fully, in order to complete the reporting for this subsector better.

118. The NIR and other source material state that under Australian conditions, emissions of $CH_4$ from manure management for animal classes other than dairy and feedlot cattle, pigs and poultry, are likely to be small. The CRF contains "0" for these emissions. The ERT considers that using "NE" rather than "0" would be more consistent with the UNFCCC Guidelines, and furthermore encourages Australia to estimate $CH_4$ emissions from manure management for all animal classes in order to provide more complete reporting for this subsector. Australia references the sources of the EF in the Workbooks rather than in the NIR. The ERT noted the need for some summary information on methodologies in the NIR, as discussed earlier.

## E. LAND-USE CHANGE AND FORESTRY (LUCF)

### 1. General overview

119. In contrast with most other Annex I Parties, in Australia this sector constitutes a net source of GHG emissions. Land clearing (LC) is the most important emissions source. The net GHG emissions from the LUCF accounted for approximately 76,253 and 39,488 Gg $CO_2$ equivalent, representing 15 and 8 per cent of national total net GHG emissions in 1990 and 1998, respectively.[8] Of major importance in LUCF is $CO_2$, accounting for 70,092 Gg in 1990. After a sharp drop in 1991, $CO_2$ emissions declined steadily to half their base year level at 35,173 Gg in 1998.

#### 1.1. Verification and QA/QC approaches

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8 "Net GHG emissions" refers to $CO_2$ emissions and removals, and emissions of $CH_4$ and $N_2O$, expressed in terms of $CO_2$ equivalent.

120. State and Territory agencies provide data on LC, while the Bureau of Rural Science and ABARE provide data related to forestry. Quality control checks are performed at the State agencies and at AGO upon receipt of such data, as outlined in the report overview. The completed inventory is circulated for feedback to State agencies and their experts. In the ERT's view, the presentation of information on QA/QC in the NIR could be improved in order better to understand the verification steps in place.

### 1.2. Completeness

121. The Australian inventory can be considered as largely complete given that it covers all major sources of C fluxes identified by the IPCC Guidelines and also provides full coverage of non-$CO_2$ gases ($CH_4$, $N_2O$, CO, $NO_x$ and NMVOC) associated with burning. Australia reported estimates under *5.A Changes in forest and other woody biomass stocks*, *5.B Forest and grassland conversion*, *5.C $CO_2$ emissions and removals from soils,* and under *5.E Other*. In line with the IPCC Guidelines *5.C Abandonment of managed lands* is considered to be "NA" because abandoned lands are generally degraded due to problems of salinity or they are used for grazing.[9] The CRF was found to be complete in that all cells of table 5 have been filled in with either numerical information or indicators. Nevertheless, the team noted that some potential sources of $CO_2$ emissions and removals might not have been taken into account, such as cultivation of mineral and organic soils, liming of agricultural soils, and forest soils currently reported as NA.

### 1.3. Transparency

122. The information on methodologies and assumptions in the methodology supplements and the worksheets in the NIR for LUCF did provide sufficient level of detail to understand how estimates have been derived (see also the section on consistency with guidelines). However, the team noted a lack of explanations for source categories not considered in the LUCF inventory such as sources under the $CO_2$ emissions and removals from soils category, see above.[10]

### 1.4. Recalculations

123. Australia recalculated 1990 to 1997 estimates for changes in forest and other woody biomass stocks, and for forest and grassland conversion LC, to incorporate minor corrections to the calculations and revisions to previous years' LC rates. Effects of these revisions for these categories were generally small, around 1-2 per cent, but reached up to 8 per cent in 1997. $CO_2$ emissions and removals from soils and prescribed burning and wildfire in forests (reported under 5.E "other") had not been revised. Recalculations have currently been kept to a minimum, in view of the upcoming NCAS (see next paragraph). The ERT noted that recalculations in this sector were reported adequately in tables 8(a) and 8(b) of the CRF and were documented in a very transparent manner. All recalculated AD have been provided in the methodology supplements.

### 1.5. Uncertainties

124. Australia provided qualitative uncertainty estimates for LUCF consistent with the IPCC Guidelines. An assessment of uncertainties was made using expert judgement for the most important underlying parameters and for emissions and removals estimates influencing overall

[9] IPCC methodology states that only natural lands regrowing towards a natural state should be included in the inventory.
[10] In CRF table 5, Australia reported all not-considered source/sink categories as NA. For categories reported as NA, the UNFCCC Guidelines do not specifically request an explanation in the completeness table (table 9) of the CRF.

uncertainty.  Availability of revised, remotely-sensed data for some years and States has significantly reduced the uncertainty from this source.  Nevertheless, uncertainties for the entire sector remain high, due to the very large uncertainty associated with land clearing rates (more than 50 per cent) and other uncertain parameters such as soil carbon and decay rates. Uncertainties of LUCF estimates are currently difficult to reduce, but significant reductions are expected under the NCAS.

### 1.6. Consistency with UNFCCC and IPCC guidelines

125. In general, Australia complied with the UNFCCC reporting guidelines for LUCF, both with respect to the CRF and the NIR.  Australia provided 1990 to1998 emission and removal estimates for all categories relevant to its national circumstances, using table 5 of the CRF. Australia provided a separate NIR for LUCF that includes modified worksheets from the IPCC Guidelines for all reported categories, providing for AD, EFs and other underlying parameters. These worksheets also include NMVOC emissions from burning even though the CRF does not require this.

### 1.7 Previous reviews

126. The S&A report noted that tables 5A to 5D of the CRF were not provided. This is in line with the UNFCCC Reporting Guidelines which confine the use of these tables to Parties using the IPCC default methodology.

## 2. Significant source and sink categories

### 2.1. Changes in forest and other woody biomass stocks

127. Forestry $CO_2$ emissions and removals estimates reported under this IPCC category constituted a net sink accounting for 24,436 and 21,649 Gg of $CO_2$ removals in 1990 and 1998, respectively, which would offset 5 and 4 per cent of the total net GHG emissions in both years respectively.  Net removals from forestry activities steadily declined by 11 per cent from 1990 to 1998, mainly due to increased harvesting emissions.

***Methodologies, activity data and emission factors***

128. Australia uses a CS methodology that is consistent with the IPCC Guidelines.  The major difference from IPCC methodology is that forestry sector wood products are assigned to decay pools of 3 to 50 years.  Australia defines a forest as an area covered by all stands exceeding two metres’ height with existing or potential projective cover of over-storey strata about equal to or greater than 20 per cent.  This definition includes Australia’s diverse native forests and plantations, regardless of age.

129. Main sources of AD were annual forest harvesting statistics supplied by ABARE and area data based on the national plantation inventory supplied by Bureau of Resource Sciences. Plantation and forest data are specified by eight classes in the modified IPCC worksheets and were explained briefly in the workbooks.

130. EFs and other parameters are both IPCC default values (e.g. carbon content of dry matter (0.5)) and CS values, where available.  Details of where the CS data have been used are in the NIR.  The ERT learned that as a general approach to selection of emission and conversion factors, IPCC default values are used as a starting point until CS data can be assessed by national

experts. The ERT noted that some of the parameters, such as biomass conversion/expansion ratios, varied from year to year. Australian officials explained that parameters given in the worksheets do not represent the actual values used in the calculations but are back-calculated figures. Data provided in the worksheets are country-averaged values.

131. Australia reported all forestry estimates under subcategory 5.A.5 Other, while subcategories identified by the IPCC, 5A1 (tropical forests), 5A2 (temperate forest), 5A3 (boreal forest) and 5A4 (grassland/tundra) are reported as NA. Australian officials explained that due to limitations in the currently available data it is not possible to report the $CO_2$ emissions and removals using the IPCC forest subcategories. Forestry estimates were therefore classified into managed native forest and plantations for $CO_2$ removals, and commercial harvest and fuelwood consumed for $CO_2$ emissions. Also, due to data collection methods, it was not possible to separate the $CO_2$ emissions into managed forests and plantations.

## 2.2. Forest and grassland conversion

132. For Australia, $CO_2$ emissions from LC are the most significant source of $CO_2$ emissions from LUCF. Given the high amount of $CO_2$ emissions resulting from this activity and the very high uncertainty associated with currently available estimates, this source should be considered as a *key* source.[11] In 1990 and 1998, this source accounted for 98,752 Gg and 61,046 Gg of $CO_2$, corresponding to 28 and 16 per cent of national total net $CO_2$ emissions in those years.[12]

### *Methodologies, activity data and emission factors*

133. To estimate emissions/removals from LC, Australia uses a CS methodology broadly consistent with the IPCC methodology. The ERT noted that Australia reported all estimates relating to LC under subcategory 5.B.5 Other, while subcategories identified by the IPCC, 5B1 (tropical forests), 5B2 (temperate forest), 5B3 (boreal forest) and 5B4 (grassland/tundra) were reported as NA. Australia uses the following forest classes: Tropical and temperate closed forests, Open forests and Woodland and scrub, which better reflect their vegetation and data availability.

134. A major difference from IPCC methodology is that Australia reports both $CO_2$ emissions and removals from LC. The removals are associated with regrowth of woody biomass after LC, which occurs mainly in Queensland and New South Wales. IPCC methodology was adapted accordingly, by calculating emissions directly from the area cleared, taking into account only the biomass before conversion. Removals from biomass left after conversion are estimated in a separate step together with biomass regrowth removals. Due to limitations in the CRF removals associated with LC were reported under category 5.E Other.[13] This approach for estimating LC emissions and removals was found to be consistent with the IPCC methodology, given that it better reflects Australia's national circumstances. Another difference from IPCC methodology is that both belowground and aboveground carbon were estimated. Based on expert judgment, Australia assumes an exponential decay of soil carbon after LC, as opposed to the IPCC Guidelines, where soil carbon decay is assumed to be linear.

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[11] A categorization into key and non-key sources has not been made for the LUCF sector, given that the Good Practice Guidance report currently does not provide any guidance on this sector.

[12] These figures present "net"$CO_2$ emissions from land clearing by taking into account $CO_2$ removals reported under 5.E Other for regrowth associated with land clearing.

[13] Cells for reporting removals from 5.B Forest and grassland conversion are shaded in table 5 of the CRF, thereby indicating that no entries should be made in such cells.

135. Annual LC data were supplied to AGO by the States and territories which provide LC rates based on either remote sensing data or LC permits. Definitions for forest classes and disaggregated data according to States are provided in the workbooks. However, AD were gathered differently across time periods due to improved data availability in later years. Associated with this is not only a high uncertainty in the numbers but also an inconsistency in the time series and a high uncertainty in the trend. For this reason, in its NIR and overall trends analysis, Australia treated LC estimates separately from other LUCF categories. As for EFs and other parameters, both IPCC default values (e.g. the IPCC default value for carbon fraction of biomass was 0.5) and CS parameters have been used.

***Previous reviews***

136. The S&A report noted that $CO_2$ emissions from forest and grassland conversion decreased sharply by 25 per cent in 1991. The ERT learned that the high estimate for 1990, which is considered to be extremely uncertain, is a result of the way LC rates were previously calculated. The methodology used from 1980 to 1990 was different from the methodology used from 1991 to 1998. For the States with major LC, such as New South Wales and Queensland, remote sensing data became more available, providing ground-truth data over the trend between 1991 and 1998. Robust estimates of LC are expected to be produced through Australia's NCAS.

### 2.3 $CO_2$ emissions and removals from soils

137. Under this category Australia reports a $CO_2$ removal from the conversion of unimproved pasture to improved pasture resulting in a net increase in soil carbon, and minimum tillage. As was noted in the S&A report, the same estimate was reported for all years 1990 to 1998. Australia acknowledges that this value is highly uncertain, given that information on soil carbon is currently very limited.

## 3. Areas for further improvement

### 3.1 Identified by the Party

138. Australian efforts to improve its LUCF estimates include the launch in 1998 of a programme to develop an NCAS as discussed in the NIR. This NCAS will address most of the current weaknesses of the LUCF estimates. Particularly, it should provide for a more robust and rigorous accounting of emissions and removals, and should enhance transparency in reporting as well as reduce uncertainties. It will also allow for coverage of emissions and removals from soil carbon. The ERT also learned that a new carbon soil map is being constructed for Australia, and that greater use of remote sensing data is being made. Unification of the forest type, for a global standard, will be discussed.

### 3.2 Identified by the ERT

139. The ERT noted several problems relating to methods, data limitations and uncertainties outlined in the main part of the report. Of major concern is the high uncertainty associated with LC estimates, particularly data collection methods for different years in various States that lead to significant time series inconsistencies and result in a highly unreliable base year figure for the entire LUCF sector.

140. In the ERT's view, data collection methods in the forestry sector should allow for a distinction between tropical and temperate forests, in States where both types exist. Also,

reporting of AD disaggregated by States and territories for forestry activities would enhance transparency in this category. Further, data should be collected in such a way as to enable reporting of both emissions and removals using the same forest subcategories.

141. The team also noted that soil carbon might not currently be completely covered in the inventory, due to data limitations. A reassessment of assumptions regarding forest soils, might allow for a better coverage of this source. Liming of agricultural soils is a source that could be considered in the future. These source categories are currently reported as NA in the CRF. The ERT believes that the indicator NE should be reported in the CRF.

142. The team also emphasized the need expressed by Australia in the workbook to reassess the assumption which considers the net flux of carbon associated with land abandonment to be zero. Such a reassessment or even peer-review would enhance certainty that regrowth of abandoned agricultural lands is not taking place in Australia.

143. The ERT would also recommend reporting of CRF tables 5.A to 5.D although this is not required by the UNFCCC Guidelines as Australia uses a country-specific methodology. Such reporting would, however, enable comparison with other countries and facilitate understanding of the magnitude of the different parameters defining emissions and removals estimates in Australia. The ERT acknowledges that ongoing work on the NCAS could address these issues.

## F. WASTE

### 1. General overview

144. The sector contributed 3.2 per cent of total national emissions in 1998. The only key source category is $CH_4$ emissions from solid waste disposal on land, which accounted for over 90 per cent of the sector, representing 2.9 per cent of the total national emissions. The rate of $CH_4$ recovery from the waste sector has increased from a negligible amount in 1993 to 13.0 per cent (1998). This resulted in a 1.1 per cent decline in total net sectoral emissions from 1997 to 1998.

#### 1.1. Verification and QA/QC approaches

145. The AGO contracted Burnbank Consulting Pty Ltd. to compile the sectoral inventory. The subject matter experts within the AGO conducted the internal quality checks of the consultant’s reports, as well as processing, documenting and archiving all the relevant reports for the waste sector.

#### 1.2. Completeness

146. The NIR covers all the sub-sources of the sector for the 1990-1998 period. A 25-year time series was derived to support a CS tier 2 level methodology that is different from the FOD method. The sectoral CRF tables reported $CH_4$, NMVOCs, and $CO_2$ from relevant subsectors. $N_2O$ emissions from human sewage, and other gases ($NO_x$, CO) were reported as NE due to the lack of CS methodologies. The ERT noted that Australia could use the tier 1 IPCC default methodology consistent with the Good Practice Guidance until a CS methodology is developed and approved.

#### 1.3. Transparency

147. Methodologies for emission estimations from waste are very well documented in the workbooks, including for example the regression analysis for $CH_4$ emissions from solid waste disposal sites (SWDSs). However, most of the methodologies yield relatively low results compared with the IPCC default method. Such an outcome requires further verification, however, it is well recognized by IPCC experts that the default methodology overestimates $CH_4$ emissions because it assumes that all $CH_4$ is emitted in the year that solid waste is placed.

### 1.4. Uncertainties

148. Uncertainties for the reported gases were estimated via qualitative assessment. The uncertainties were estimated to be greater than 50 per cent based on expert judgement. The major sources of uncertainty are $CH_4$ potential, waste composition, per capita waste disposal, and growth rate. The ERT noted that new survey data would be helpful in reducing the high degree of uncertainty, considering the large differences between the results of Australia's tier 2 methodology and the IPCC default method. Australia is encouraged to consider conducting new surveys to account for any changing trends in waste management practice (e.g. increasing solid waste recycling and industry practice under the emerging Australia and New Zealand Environment Conservation Council (ANZEEC) trade waste guidelines and Green and Organic Waste Management Strategy).

### 1.5. Recalculations

149. These are detailed in the Waste Sector Workbook 8.1 supplement and the project report submitted to the AGO by the inventory consultants. Background tables were completed in the CRF. The changes are due basically to a revision of the population data. The revision amounted to changes in the previously reported emissions ranging from 0.53 per cent in 1990 to 0.73 per cent in 1996.

### 1.6. Consistency with IPCC and UNFCCC guidelines

150. The estimations of the key source in this category, $CH_4$ emissions from SWDS, are consistent with the IPCC Guidelines. The reporting of emissions from this source in the CRF and in the NIR is also consistent with the UNFCCC Guidelines. Some minor issues and suggested improvements are reported below.

## 2. Methodologies, activity data and emission factors

151. Australian CS Workbook 8.1 has been developed and approved as containing standardized methodologies for sectoral emissions calculations and reporting guidelines. The methodologies are revised whenever necessary and included in the detailed project report. The NIR, however, does not provide a summary description of the method.

## 3. Key sources

### 3.1 Solid waste disposal sites: $CH_4$ emissions

152. SWDS of the waste sector constitute a key source. The $CH_4$ emissions from SWDS contributed 91 per cent (14,114 Gg) of sectoral emissions, which represents 3.1 per cent of total net national emissions.

***Trends***

153. The emissions from SWDS increased from 13,623 Gg (1990) to 14,114 Gg (1998), representing a 3.6 per cent increase due to increases in population and waste generation. The share of national total emissions, however, decreased from 3.5 per cent (1990) to 3.1 per cent (1998) as a result of the substantial increases in $CH_4$ capture (13 per cent) since 1993.

***Methodologies, activity data and emission factors***

154. A CS methodology different from the tier 2 IPCC methodology (i.e. FOD) has been developed. It is based on a US regression model adapted to Australia's circumstances. The model assumes a 25-year lifetime of emissions from SWDS, and $CH_4$ generation potential of 79l/kg, based on a country study in 1995. The methodology yields 50 per cent fewer emissions than the IPCC default. The latter is based on the assumption of emission released within one year after placement of the solid waste.

155. The AD was originally based on a 1994 countrywide survey of 44 local governments that maintained records on waste management for the period 1990-1993. The inventory analysis compiled by the Bureau of Industry Economics and Maunsell established the national per capita MSW generation of 2.06 kg/capita/day. The subsequent MSW per capita generation has been estimated based on an annual growth rate of 0.73 per cent. The $CH_4$ capture at the SWDS is plant-specific, and data are collected on an annual basis. Population data from 1990 to 1998 have been revised from "mean resident population" to "estimated resident population". Both are based on the calendar year, for consistency with the data for waste disposal. The changes have been documented in the 1997 Waste Sector Workbook supplement.

156. The high per capita MSW generated for Australia (2.06kg/capita/day) compared to the IPCC default (1.26 kg/capita/day) is attributed to the inclusion in the survey data of other waste generated, such as council green waste, commercial waste, some industrial waste, and building and construction waste, that are not considered in the IPCC default factor.

157. The CS factors used in the algorithm for $CH_4$ emissions estimation include a population growth rate (0.73 per cent), DOC (0.15), and gas density (79 litres $CH_4$/kg MSW). The other factors are the relative concentration of $CH_4$ in landfill gas (50 per cent), average population over a 25-year time series, and the fraction of waste to SWDSS (1.0). The IEF is approximately 50kg$CH_4$/ton MSW. The sources of the factors are documented in country Workbook 8.

## 4. Non-key sources

158. The relevant non-key sources include: $CH_4$ emissions from wastewater handling, $CH_4$ capture from SWDS and wastewater treatment plants (WWTs), and $CO_2$ emissions from waste incineration. Net $CH_4$ emissions from WWTs represent 0.3 per cent of total net national emissions and waste incineration 0.1 per cent.

### 4.1. Wastewater treatment

159. IPCC default methods were used for estimating emissions from wastewater handling systems. A 25 per cent industrial biochemical oxygen demand (BOD) load is assumed to be discharged to sewers and treated by municipal treatment plants, and a 75 per cent BOD load is assumed for industry sites. The CS fraction of BOD anaerobically treated in industrial WWTs is assumed to be 27 per cent.

160. The methodology used for estimating $CH_4$ emissions is comparable to the IPCC default methodology. CS EFs, where available, and IPCC default factors were used. $N_2Os$ were not estimated, and were hence reported as NE.

### 4.2. Waste incineration

161. Waste incineration is only a small source of emissions in Australia, contributing just 17 Gg $CO_2$ emissions. The $CO_2$ reported is emitted from the combustion of waste solvents.

## 5. Previous reviews

162. The issues identified in the S&A report were related to inconsistencies in time series and reporting of $CO_2$ emissions in sectoral tables and in the trend table 10, and a lack of estimates for $N_2O$ emissions from waste incineration and human waste. The latter was due to the absence of CS methodologies for this source.

163. The inconsistent use of indicators for $CO_2$ emissions over the time period has subsequently been rectified. Thus, the CRF data for the 1990-1995 period currently reads consistently NE, as indicated in the trends table. The ERT noted that where plant-specific emission monitoring data are not available for waste incineration, the Good Practice Guidance method for $N_2O$ emissions for hazardous waste could be applied. Similarly, the highly simplified method in the IPCC Guidelines for direct $N_2O$ emissions from wastewater disposal is considered good practice. There was therefore a consensus on recommending the use of this method.

## 6. Areas for further improvement

### Identified by the ERT

164. Australia is encouraged to improve the quality of AD used for estimating the coefficient for $CH_4$ generation in the regression model currently applied for the quantification of $CH_4$ emissions. This would require further work in the characterization of municipal solid waste. The latter is very crucial because the current programmes for recycling solid waste will significantly affect the degradable organic component and $CH_4$ generation potential.

165. Further work would also be useful in the area of improving the quality of AD and EFs, and the characterization of wastewater generation and capture of $CH_4$. In addition, the ERT noted the need to improve the estimates of $N_2O$ emissions, by including $N_2O$ emissions estimates from human waste and incineration, using IPCC methods until CS methods are developed.

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