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

(Centralized review)

A. GENERAL OVERVIEW

1. Introduction

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

2. In response to the mandate by the COP, the secretariat coordinated a centralized review of six national GHG inventories (Australia, Canada, Hungary, Japan, the Netherlands and New Zealand) submitted in 2000, which took place from 7 to 11 May 2001. The review was carried out by a team of nominated experts from the roster of experts working at the headquarters of the UNFCCC secretariat in Bonn. The members of the team were: Mr. Ayite-Lo Ajavon (Togo), Mr. Wiley Barbour (United States of America), Mr. Pascal Boeckx (Belgium), Mr. Jose Gonzalez Migues (Brazil), Mr. Tomas Hernandez-Tejeda (Mexico), Mr. Klaus Radunsky (Austria), Mr. Yiannis Sarafidis (Greece), Ms Sirintornthep Towprayoon (Thailand) and Mr. Hristo Vassilev (Bulgaria). The review was coordinated by Mr. Stylianos Pesmajoglou (UNFCCC secretariat). Mr. Wiley Barbour and Mr. Jose Gonzalez Migues were lead-authors of this report, and also served as sector experts.

3. The main overall objective of the centralized review of the GHG inventories was to ensure that the Conference of the Parties had adequate information on the GHG inventories. The review should further assess the progress of the Parties toward fulfilling the requirement outlined in the UNFCCC reporting guidelines on annual inventories (FCCC/CP/1999/7). In this context, the review team checked the responses of the Parties to questions raised in previous stages of the review process and the consistency of the inventory submission with the UNFCCC reporting guidelines and the *Revised 1996 Intergovernmental Panel on Climate Change Guidelines for*

[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 (3) indicates that for Australia, this is a centralized review report.

[2] Document FCCC/CP/1999/7, in particular the UNFCCC review guidelines (pages 109 to 114), and decision 6/CP.5 (page 121 to 122)

National Greenhouse Gas Inventories (hereinafter referred to as the IPCC guidelines), and identified possible areas of improvement in the inventories of the six Annex I Parties. Each inventory expert reviewed the information submitted for specific IPCC sectors and each IPCC sector was covered by two experts.

4. The review team has also assessed to a certain degree whether the reporting fulfils the requirements included in the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC good practice guidance), although the IPCC good practice guidance was not published at the time the inventory was submitted and could not, therefore, have been used in the compilation of the inventory.

5. The UNFCCC secretariat provided the review team with all necessary technical guidance, information and data, such as national inventory data reported according to the Common Reporting Format (CRF) submitted in the year 2000, National Inventory Reports (NIRs) for the year 2000, the synthesis and assessment report of GHG inventories prepared by the secretariat, and comments from the Parties on the synthesis and assessment report.

2. Overall findings

6. Australia's NIR conforms to the current IPCC inventory standards and appears largely consistent with the principles recently developed through the IPCC good practice guidance.

3. Completeness

7. Australia's NIR was found to be largely complete. Indirect N_2O emissions from agricultural soils have not been estimated, and due to lack of industry data, ammonia production has not been addressed. Reporting of synthetic gases is incomplete; emissions from the consumption of halocarbons and SF_6 have not been estimated, although they are likely to be a key source.

4. Transparency

8. Australia's NIR is generally well documented, although in some cases it was necessary to refer to the Australian Methodology Workbooks (1998 workbooks with methodology supplements) in order to understand the assumptions and methods used. Overall, the documentation provides thorough coverage of emission factors, detailed description of the sources and quality of activity data and brief coverage of quality control and uncertainty analysis. Transparency and reporting of the Land Use Change and Forestry section could be improved by providing additional details on the country specific methodology used, explaining use of the "other" category, and discussing the basis for selection of categorization schemes, methods and data.

5. Data sources used for centralized review

5.1 National greenhouse gas emission inventory report

9. Australia submitted a NIR on 13 July 2000. Australia also provided 1998 workbooks with methodology supplements to previously published workbooks for fuel combustion activities, fugitive fuel emissions and waste. The methodology supplements include worksheets with activity data, emission factors and other parameters used for the calculation of emissions estimates. The NIR mentions that, for each IPCC sector, quality control checks for emission estimates, emission factors and data input were made.

10. The NIR was accompanied by the CRF tables. Recalculation tables from 1990 to 1997 have been reported. Most of the calculation worksheets were provided. The documentation has been provided for all sheets where appropriate.

5.2 Common reporting format

11. Australia submitted inventory data for the years 1990 to 1998 using the CRF.

12. Indicators were used throughout all tables of the CRF.

5.3 Synthesis and assessment report (S&A report)

13. Australia provided a detailed response to the S&A report clarifying many technical details and the review team members were able to take these comments into account.

14. The data that were provided using the CRF in electronic format were reproduced in the NIR. No inconsistencies were found between the CRF data and activity data and emissions estimates in the worksheets that were incorporated in the NIR.

No time series inconsistencies were identified in the S&A report for Australia. Emissions and activity data trends do not indicate any major deviations.

B. ENERGY

1. General overview

1.1 Completeness

15. The Energy section was found to be complete and well developed.

1.2 Transparency

16. The energy sector is well documented with details presented for activity data, emission factors and methods selection. Country specific methods are described, trends are discussed and explanations provided for decreasing implied emission factors (IEFs), where appropriate.

1.3 Verification procedures

17. Several categories (mobile sources in particular) have been revised due to detection of errors in previous submittals. This is evidence of verification efforts at work. Estimates of uncertainty have also been provided, based on both expert judgements and use of Monte Carlo analysis.

2. Reference approach

18. Calculations based on GCV. There is no information on how to calculate emissions using net calorific value (NCV) in the NIR. Deviation in CO_2 emissions less than 2 per cent and explained.

3. Feed stocks

19. Feed stocks are recorded together with the additional information required. There is a change in the percentage of carbon stored in lubricants (from 50 to 60 per cent) as a result of advice of the Australian Institute of Petroleum. The change was only applied to the 1998 inventory as is based on an assumed change in technology.

20. The NIR also mention new consideration of the fraction of lubricants that are reused/recycled as fuel oil for 1998 only. The NIR states that these two changes result in an increase of reported emissions of 252 Gg CO_2. This represents the change in emissions for 1998 relative to the previous methodology.

4. Specific findings

4.1 Fugitive emissions from oil and gas

21. *Emissions:* Australia's NIR (table 3) reports that total greenhouse gas emissions from oil and gas amounted for 2.8 per cent of total net emissions in 1998. Values in the CRF tables match the NIR.

22. *Methodology:* The 1998 workbook 2.1 contains detailed discussion of this category and the approach used to estimate emissions. Emissions from oil and gas flaring are combined.

23. *Emission factors:* The IEFs vary considerably over the period. The IEFs for CH_4 and CO_2 from oil and gas flaring decreased by 58 per cent from 1990 to 1998. A reduction in emissions from flaring is noted in the NIR, and the workbook explains the need to approach this category in a detailed site-specific manner.

24. *Activity data:* Oil and gas productions have increased over the period.

25. *Completeness:* This category has been completely addressed in a transparent manner.

26. *Uncertainty:* The NIR and workbook 2.1 both contain a discussion of uncertainties in this category.

4.2 Fugitive emissions from solid fuels

27. *Emissions:* Fugitive emissions from coal production increased by 17 per cent over the period, to 889.3 Gg CH_4 in 1998.

28. *Methodology:* Australia's 1998 workbook 2.1 contains detailed discussion of this category and the approach used to estimate emissions. Underground mines are categorized by level of gas released (A or B), with the majority falling into the "gassy" category A although growth in production has generally favoured the class B mines. Values in the CRF tables match the NIR.

29. *Activity data:* Coal production increased by 42 per cent over the period, and activity data matches IEA statistics very well.

30. *Completeness:* This category has been completely addressed.

31. *Uncertainty:* The NIR and workbook 2.1 both contain a discussion of uncertainties in this category.

4.3 Stationary combustion - CO_2 emissions

32. *Emission trends:* CO_2 emissions from stationary combustion (liquid, solid and gaseous fuels) are key sources for Australia, representing the 53 per cent of all reported emissions in 1998 (without LUCF). Australia reports CO_2 emissions from stationary combustion increasing from 264 Mt in 1990 to 320 Mt in 1998 (21 per cent increase compared to 1990):

(a) CO_2 emissions from the stationary combustion of liquid fuels represent the 6 per cent of all reported emissions in 1998 (without LUCF) and there was a 10 per cent increase compared to 1990;

(b) CO_2 emissions from the stationary combustion of solid fuels represent the 38 per cent of all reported emissions in 1998 (without LUCF) and there was a 27 per cent increase compared to 1990;

(c) CO_2 emissions from the stationary combustion of gaseous fuels represent the 9 per cent of all reported emissions in 1998 (without LUCF) and there was a 24 per cent increase compared to 1990.

33. *Methodologies:* Estimation of emissions is based on the IPCC tier 2 method, except for “Other sectors” and "Other" where a combination of tier 1 and tier 2 method is applied (information reported in CRF). The methodologies are presented in the workbook for Fuel Combustion Activities.

34. *Emission factors:* The emission factors used are country specific and are described in the workbook for Fuel Combustion Activities.

(a) The IEFs for solid, liquid and gaseous fuels are comparable with the IEFs estimated for other countries (1998 inventory);

(b) The IEFs for liquid and gaseous fuels fall towards the lower limit of the range;

(c) As explained in Australia’s written response to the Synthesis and Assessment report, a transcription error lead to an incorrect IEF for the residential sector in 1994. This item has been noted and corrected in CRF Tables.

35. *Activity data:* Activity data are drawn from official statistics or from industry.

36. *Recalculations:* A new methodology adopted for this NIR assumes that all coke supplied to the iron and steel sector is fully oxidised to CO_2, so that the intermediate step of blast furnace gas formation is entirely ignored. The new methodology has been used to recalculate emissions back to 1990 and there was an increase in emissions by 2.7 Mt CO_2-e in 1990.

37. *Completeness:* All sub-sectors are covered.

38. *Uncertainty:* Estimates of uncertainty are presented in the NIR and are based either on expert judgement using the methodology recommended by the IPCC guidelines or Monte Carlo simulations (electricity generation, CO_2 and N_2O emissions).

4.4 Mobile combustion - CO_2 emissions

39. *Emission trends:* CO_2 emissions from mobile combustion (road transportation and civil aviation) are key sources for Australia, representing 14 per cent of all reported emissions in 1998

(without LUCF). Australia reports that CO_2 emissions from the above-mentioned sources increased from 55.3 Mt in 1990 to 65.1 Mt in 1998 (18 per cent increase compared to 1990):

(a) CO_2 emissions from mobile combustion - road transportation represent 13 per cent of all reported emissions in 1998 (without LUCF) and there was a 15 per cent increase compared to 1990;

(b) CO_2 emissions from mobile combustion - civil aviation represent 1 per cent of all reported emissions in 1998 (without LUCF) and there was a 72 per cent increase compared to 1990.

40. *Methodologies:* Estimation of emissions is based on a combination of IPCC tier 1 and tier 2 method as stated in the CRF for 1998. The methodologies are presented in the workbook for transport.

41. *Emission factors:* The emission factors used are country specific and are described in the workbook for transport. The IEFs for liquid fuels in transport fall towards the lower limit of the range of the IEFs calculated for all countries (based on comparison of 1998 data).

42. *Activity data:* Fuel consumption data are provided by ABARE, while the allocation of this consumption to required categories is based on expert judgement.

43. *Recalculations:* The recalculations reported are:

(a) An error was detected by the Australian inventory group in earlier inventory emissions estimates from road transportation that led to a slight change in the greenhouse gas emissions estimates from all previous years (1990-1997). The consumption data for ADO fuel in the road transportation sub-sector was over-allocated by 0.5 per cent;

(b) An error in the fuel consumption rates of medium and heavy trucks for ADO was also corrected. The allocation of fuel consumption values for a given age was incorrect (e.g. the heavy truck fleet in the 1997 inventory was allocated a fuel consumption rate relevant for the heavy truck fleet in 1995). These values were amended for the years 1995 to 1998;

(c) Since natural gas consumption for railways is not used as a transportation fuel but as a heating source in railways and workshops, the emissions from railway stations by combustion of natural gas are now accounted for in 1A4a (previously 1A3c).

44. *Completeness:* All sub-sectors are covered.

45. *Uncertainty:* Estimates of uncertainty are presented in the NIR and are based on expert judgement using the methodology recommended by the IPCC guidelines for the whole sector and Monte Carlo simulations for passenger vehicles and heavy trucks.

5. Bunker fuels

46. Fuel consumption for international navigation and aviation is reported in 1998 CRF.

47. International and domestic fuel consumption for navigation and aviation are reported separately by the ABARE.

6. Weather related-adjustments

48. In accordance with the IPCC guidelines, the methodologies used do not include weather-related adjustments of emissions.

7. Questions and issues from previous review stages

49. The S&A report stated "CO_2 emissions from fuel combustion were calculated using the reference approach and the sectoral approach. There is a difference of only -0.96 per cent between the estimates". The Australia answer states: "Considerable effort is devoted to ensuring that both activity data and emission factors are applied consistently between the two approaches, notwithstanding the appreciable differences in methodologies and derivations."

50. In relation to the use of GCV to calculate emissions, the answer states "in all Australian national energy statistics, the specific energy content of fuels and hence energy consumption by each sector of the economy are expressed in terms of GCV."

51. The S&A report stated that the IEFs should be about 5 per cent lower for solid and liquid fuels and 9 per cent lower for gaseous fuels than other countries. The response of Australia was "this sounds appropriate as in the transport workbook the IEA is quoted as stating that NCV is 5 per cent lower for oil and coal, and 10 per cent for natural gas (OECD 1991)."

8. Questions and issues from Party's response to draft central review report

52. Australia provided detailed comments in response to the draft review report, which were very helpful in clarifying the issues for the reviewer team. The review team noted that Australia's detailed written response to the Synthesis and Assessment Report provided clear guidance on methodological issues, emission factors, and numeric transcription errors.

C. INDUSTRIAL PROCESSES

1. General overview

1.1 Completeness

53. Emissions are not estimated for 2.A.6. Mineral Products: Road paving with asphalt CO_2 (there are no methodologies provided in the IPCC guidelines for estimating CO_2 from this sub-sector), 2.B.1. Chemical industry: Ammonia production, 2.B.5. Chemical industry: Other, 2.D.1, Other production: Pulp and paper. Table 9 of the CRF states "no data are available" to estimate these source categories.

54. For 2.B.4. Chemical industry: Carbide production table 9 reads "there is no carbide production in Australia but there is acetylene use produced from imported calcium carbide. "No methodology developed" for 2.C.5. Metal Production: Other and 2.D.2. Other Production: Food and drink. For CH_4 emissions in 2.B.5. Chemical industry: Other, table 9 states "no data are available for polymers and other chemicals such as carbon black and fertiliser production." For N_2O in 3.D. Other "No data are available." For HFCs, PFCs and SF_6 "No reliable data are available.

1.2 Transparency

55. Details and explanation to the extent possible.

1.3 Recalculations

56. Australia provided recalculated estimates (table 8 (a)) and explanatory information for these calculations (tables 8 (b)) for the years 1990 to 1997. The effect of the recalculations (as reported in the CRF tables) was an increase of 0.35 per cent in the total CO_2 equivalent emissions without land-use change and forestry for the base year (1990). For the year 1997, the effect of the recalculations was 0.02 per cent.

1.4 Methodologies

57. IPCC tier 2/country-specific for CO_2 and CH_4 and IPCC tier 1/default for N_2O. IPCC tier 1/ country-specific and IPCC tier 2/country-specific for PFCs and SF_6, respectively.

1.5 Uncertainties

58. Qualitative assessments of the uncertainty are made (high for SF_6, medium for CO_2 and PFCs, and low for CH_4 and N_2O). Quantitative estimates are made for CO_2 emissions from cement clinker, lime and aluminium.

2. Mineral sector

59. The review team noted that the CO_2 IEF from lime production is below the default IPCC range. Australia's response to S&A report explained that the IPCC emission factor is based on 100 per cent pure lime. As lime is rarely this pure in practice, Australia adjusts the purity rating to a range of 85 to 95 per cent.

60. CO_2 IEF from limestone and dolomite use is below IPCC range. Australia noted in their comments that the reasons for this outcome are being analysed.

61. Soda Ash Production was reported as a sink. The process is described in the methodology workbook. The methodology is also described briefly in the IPCC guidelines. The sequestration is caused by the addition of a high concentration of calcium ions from the soda ash production to the seawater results in a chemical reaction between the calcium ions and carbonate. At the high pH of seawater, the calcium carbonate precipitates and equilibrium in the water is restored by absorption of carbon dioxide from the atmosphere. At equilibrium, particularly within the period of the annual inventory, the calcium carbonate does not release sequestered carbon dioxide back to the atmosphere. The outcome of the soda ash production is then a net sequestration of carbon dioxide. Australia's comments indicate a clarification of this is desirable and Australia is currently reviewing this methodology. Emissions were reported for soda ash consumption.

3. Chemical sector

62. Ammonia production was not estimated. Information available through the United Nations statistical data publications indicates a production of 450 kt.

63. Australia estimated emissions from nitric acid production. Adipic acid production does not occur in Australia.

64. Australia was unable to provide estimates for calcium carbide, ethylene and coke due to a lack of data. Silicon carbide production was reported as NO.

4. Metal sector

65. Australia's Methodology Workbook 7.1 states: "Carbon dioxide and carbon monoxide emissions resulting from metallurgical coke production and use have previously been accounted for indirectly from a consideration of the carbon content of coking coal in the fuel combustion activities." Accordingly, the "NA" code is not appropriate; IE better explains the methodology used.

66. Australia reported CO_2, CF_4 and C_2F_6 emissions from aluminium production.

67. For aluminium production, the activity data has increased over 28 per cent from the year 1990 to 1998 (from 1,235 kt to 1,589 kt), but the 1998 emission factor has decreased to 22 per cent of the initial emission factor of the year 1990. This results in a decrease of CF_4 emissions to 29.1 per cent of the 1990 value. The NIR states that the reduction in emissions is the result of technology improvements in process control and monitoring. The NIR points to significant technology changes in the aluminium smelting industry in Australia over the last decade resulting from improved management and monitoring and also technology changes that have reduced the anode effect and the associated emissions of CF_4.

68. Emissions from SF_6 used in magnesium foundries were reported, emissions from ferroalloys production were reported as NA and SF_6 emissions from aluminium foundries were reported as NO.

5. Production and consumption of HFCs and SF_6

69. Production of HFCs and SF_6 were reported as NO. Emissions from consumption of HFCs and SF_6 were not estimated (potential and actual (except for SF_6) emissions) because "available data are unreliable". SF_6 consumption (2F) is reported as NE.

70. Emissions from the IPCC subcategory 2.F.6 were not estimated as there is no semiconductor manufacturing in Australia.

6. Solvents

71. Emissions of NMVOCs are estimated. CO_2 emissions are reported as NA and N_2O emissions are reported as NE.

7. Key sources

72. No key sources were identified for the industrial processes sector for Australia.

8. Questions and issues from previous stages

73. Australia provided response to S&A report and the central review was able to take these comments into account.

74. Australia provided the following explanation: "The requirement for emissions data for synthetic gases is relatively recent compared to the other major greenhouse gases. Mechanisms have not been put in place for gathering statistics on synthetic gases. Priority is being placed on the development of comprehensive data gathering arrangements for synthetic gases."

D. AGRICULTURE

1. General overview

75. Both CRF and NIR were provided. IPCC worksheets are no longer used as these are effectively replaced by the sectoral background tables of the CRF. Agriculture contributes up to 20 per cent of the total GHG emissions. Trends are explained in the NIR. Numbers of animals are consistent throughout this chapter.

2. Specific findings

2.1 Enteric fermentation (table 4A)

76. A country specific tier 2 approach is used for this section. The IEF for dairy cattle, non-diary cattle, sheep and swine are different from the IPCC default values. However, Australia already explained this for dairy and non-dairy cattle in their answers to the Synthesis and Assessment Report. The agriculture section of the NIR is well documented. Information can be found for animal numbers and milk production; however, this is not the case for animal weights and feed digestibility. It is mentioned in the additional documentation box of the CRF that more documentation is available in the *GHG Inventory Workbook for Livestock*. Including a brief summary of the methodology in the NIR could improve transparency.

77. As with other sectors, the Workbook for Livestock is a separate document. Due to the size of the methodologies (100 pages in the case of livestock emissions) it is impractical to include these in the NIR. The methodologies are published as a series of Workbooks, which have been provided to the UNFCCC Secretariat. As the Australian methodology for estimating emissions from livestock is highly disaggregated (e.g., a matrix of 7 States and Territories x 4 seasons x 6-7 livestock classes for sheep and cattle) only weighted averages in the additional information tables have been reported.

2.2 Methane emissions from manure management (table 4B(a))

78. As explained in Australia's S&A response, the Dairy Cattle MCF is lower than the IPCC default for pasture/ranges (1 per cent vs. 1.5 per cent). About 95 per cent of all dairy manure in Australia is assumed to be void at pasture as the animals are only housed for milking purposes. In relation to the non-dairy cattle, as explained in the S&A response the Australian methodology assumes that there are no emissions associated with range kept animals, hence the typical animal mass reported is for the stall-kept animals. The IEF appear low because Australia reported the total non-dairy cattle numbers. This has been addressed and Australia has indicated that in future it will only report the feedlot cattle numbers in this table so that a more sensible IEF is produced. When this correction is made the IEF is 1.1 kg/head/yr, which is similar to other countries such as Canada.

2.3 Nitrous oxide emissions from manure management (table 4B(b))

79. The EF used is the IPCC default value. The N excretion values are country specific, but not referenced in the NIR or the documentation box in the CRF. For poultry NA is given for the N excretion. Australia indicated that this was a typographic error and that nitrogen excretion/ head has been estimated as evidenced by the estimated emission per management system reported in this table. The distribution of manure among animal waste management systems

(AWMS) is country specific. There are no references mentioned in the additional documentation box or the NIR. A reference to the information in the methodology workbook would improve transparency.

2.4 Rice cultivation (table 4C)

80. The IPCC default methodology is used.

2.5 Agricultural soils (table 4D)

81. The additional information boxes have not been completed as they are not appropriate to the Australian methodology. From table 4B(b) it appears that $FRAC_{graz}$ is high, namely 0.94. This might cause a problem for the calculation of FAW when the default value for $FRAC_{gasm}$ (0.2) is used. The sum of $FRAC_{graz}$ and $FRAC_{gasm}$ is larger than 1, which will result in a negative FAW value. This problem is solved in the IPCC good practice guidance. The input data for FAW and N excretion during pasture, range and paddock are well documented in the CRF, but appear inconsistent with the data provided in table 4B(b) and table 4D.

Direct soils emissions

82. N input data for crop residues and N-fixing crops are reported as NA. Incorporation of crop residues is a considerable source of N_2O. Table 4F reports that on average 12 per cent of the crop residues are burned, thus some fraction of the crop residues should remain in the field. The IEF for histosols (0.29) is very small compared to the IPCC default value. The CS method estimates N_2O emissions from disturbed soils, which includes emissions from N-fixing crops and crop residues, cultivation of organic soils, and atmospheric nitrogen deposition.

Animal production

83. N input data under "pasture, range and paddock" do not fit with the data provided in table 4B(b). The anomaly in N input data occurs because N excretion from the minor livestock categories such as deer, goats and horses are missing in Table 4B(b). This anomaly has been noted by Australia and will be corrected in the next inventory submission. The EF is very low and an explanation was provided in the S&A response (caused by use of urine EF of 0.4 per cent compared with IPCC 1.25 per cent). Documentation is given in the methodology workbook 5.1.

Indirect emissions

84. Indirect N_2O emissions are not calculated. In some countries, N_2O-indirect can constitute up to 1/3 of the N_2O emission from soils and is thus an important N_2O source. Australian soils tend to be N limited and the N output of the major catchment area is $<100^{th}$ of European/USA levels. Leaching from Australian soils is considered to be small.

2.6 Savannah burning (table 4E)

85. For Australia the first column in table 4E presents the actual areas of savannah burnt as recorded by satellite images, hence the faction burnt is 1. This differs from standard reporting where the first column normally contains the total surface area covered by savannahs, and a fraction of savannah burnt is needed. The fraction of savannah burnt is only relevant when the actual extent of burning is unknown. The methodology distinguishes between ecological zones

(in this case States and Territories) as the fuel loads can differ significantly between them. The IEFs are identical as EFs (unit gas /mass of fuel burnt) and do not differ between zones.

2.7 Agricultural residue burning (table 4F)

86. The values for "residue to crop ratio", "dry matter fraction" and "N fraction in biomass of residue" are different for sugar cane and wheat. Australia stated in comments to the review team that it is not possible to differentiate these factors for the other crop types due to a lack of data.

3. Quality assessment/quality control QA/QC

87. A cross-checking of input data has been carried out. Agricultural data is collected through national surveys and census conducted by national institutions who have documented QA/QC procedures. This is consistent with the IPCC good practice guidance.

4. Uncertainty

88. Monte Carlo analysis was performed. When this was not possible expert judgements were used to assess the uncertainty.

E. LAND-USE CHANGE AND FORESTRY (LUCF)

1. General overview

89. According to summary table 2, in 1998, net emissions from the LUCF sector were estimated as 39,485.90 Gg carbon dioxide equivalent (Gg CO_2-e). This corresponds to 8.2 per cent of the total GHG emissions in 1998.

90. Australia employs a country-specific method for CO_2 flux estimation.[3] It was not possible to compare the country-specific methods with other methodologies during the expert review. No explanation has been provided in the NIR for the choice of a particular methodology for this sector.

91. Comparability with other countries' information is difficult to assess. Available Australian data are not comparable to the forest and grassland categories as defined by the IPCC guidelines for sectors 5A, 5B and 5D. Data have been provided for categories unique for Australia and country-specific methodologies have been developed to suit the available information.

92. Australia provided the following additional information as a comment to the 1st draft: Australian information on forests and grasslands are currently unavailable in a format that allows allocation of emissions according to the particular forest and soils categories given in the common reporting format (CRF). However, Australia is developing a spatially explicit National Carbon Accounting System (NCAS) to provide estimates of emissions from the Land-Use Change and Forestry sector. When the NCAS is operational, Australia should be able to produce summary information, which is consistent with the CRF forest and soil categories. Australia

[3] Definitions of the forest and grassland categories currently used are provided in the Workbook for CO_2 from the Biosphere 4.2.

may have later views based on experiences with the NCAS program once it becomes fully operational.

2. Findings

2.1 Changes in forest and other woody biomass stocks (table 5.A)

93. *Completeness*: Data have been provided for subsector 5.A.5 "Others" only, the categories being managed native forest and plantations, for CO_2 removals, and commercial harvest and fuelwood consumed for CO_2 emissions. This makes it impossible to assess CO_2 emissions for the two types of forest. Australia provided the following additional information as a comment to the 1st draft: Australian data is not available in a format that allows us to report the CO_2 emissions and removals using the same forest subcategories, e.g., round wood removal data only identifies hardwood and softwood.

94. Estimated emissions for the sum of commercial harvest and fuelwood consumed show a small increase from 46,907 Gg CO_2 to 51,780 Gg CO_2 from 1990 to 1998. The net CO_2 emissions/removals have decreased by 11.4 per cent during the same period. These findings are reasonably consistent. Most of the CO_2 emissions come from commercial harvest.

95. The categories 5.A.1 "Tropical forests, 5.A.2 "Temperate forests", 5.A.3 "Boreal forests" and 5.A.4 "Grassland/tundra" have been classified as NA. No rationale is provided as to why the categories "Tropical forests" and "Temperate forests" would not be applicable to Australia. Australia provided the following additional information as a comment to the 1st draft: These categories are not applicable to the current Australian methodology and data sources as outlined in the Methodology Workbook.

96. It is noted that the indicator NA was used for the harvested wood category. However, the NIR does not provide an explanation. Australia provided the following additional information as a comment to the 1st draft: Harvested wood is not an explicit IPCC source category. The emissions categories reported by Australia (i.e. commercial harvest and fuel wood consumed) are consistent with the IPCC tables and the sectoral background tables of the new CRF and allow for greater transparency in reporting.

97. *Consistency*: The review team notes that for the time being there seems to be a lack of consistency between the "Other" categories as defined under subsectors 5.A and 5.B. As indicated in paragraph 104 this problem may be solved in the future.

98. *Recalculations*: The NIR describes several changes in the methodology, which did not induce major effects on data. Reasonable improvements have been made. It is acknowledged that the quantitative effects of recalculations have been provided.

99. *Transparency*: There is enough information on both methodological issues and indicators (emission and conversion factors and activity data). Additional information explaining the choice of categories, methods, indicators and emission/conversion factors would facilitate a more in-depth review.

100. *Methodology*: Country-specific method for CO_2: Owing to a lack of information, it was not possible to check for comparability of data/methodologies for this sector. However, Australia has pointed out that the methodology is described in the methodology workbook 4.4.

101. *Emission and conversion factors*: The following information has been taken from worksheets included in appendix table 5 of the NIR for the LUCF sector:

Category	Average annual growth rate (t dm/ha)	Biomass Conversion/ Expansion Ratio (t dm/m^3)
Rainforests	1.15	
Tall dense eucalyptus	4.81	
Medium dense	1.90	
Medium sparse	0.35	
Callitris	0.51	
Coniferous plantation	7.10	
Broadleaf plantation	8.65	
Other forests	0.47	
Hardwood		1.19-1.38
Softwood		0.75-0.89

Carbon fraction of dry matter: 0.5

102. It is noted that the biomass conversion/expansion ratio varies from year to year. Australia informed the review team that the methodology for estimating biomass removed (kt dm) applies different decay times to different wood products and includes emissions from wood harvest in previous years. The roundwood removals in m^3 represent the tonnes removed in the inventory year. As the biomass conversion/expansion ratio is an implied value it changes year to year. However, the above factors compare well with those in the literature. In addition to the above indicators, a more detailed description of the figures for total forest carbon uptake and underlying annual growth per hectare in biomass, as well as for conversion and expansion factors, would be helpful for a better understanding of the data.

103. *Activity data*: Activity data for area of forest/biomass stocks and commercial harvest have been provided for the years 1990 to 1998 in the worksheets included in appendix table 5 of the NIR for the LUCF sector. However, a reference to the origins of the data and a short description of the methodology used to estimate them would be welcome.

Category	Area of forest/biomass stocks (kha)	Commercial harvest (1000 m^2 roundwood)
Rainforests	1,333	
Tall dense eucalypt	3,235	
Medium dense	6,705	
Medium sparse	2,029	
Callitris	295	
Coniferous plantation	884-896	
Broadleaf plantation	159- 280	
Other forests	1,289	
Hardwood		9,512-10,895
Softwood		6,553-9,502

104. It is noted that throughout the period 1990 to 1998 there have been changes only in commercial harvest of softwood and the areas of coniferous and broadleaf plantation. Australia informed the review team that the data on the area of managed native forests is updated infrequently. A revision is expected shortly.

2.2 Forest and grassland conversion (table 5.B)

105. *Completeness*: Data have been provided for category 5.B.5 for emissions of CO_2, CH_4, N_2O, NO_X and CO. The source categories were divided into above- and below-ground and specified as closed tropical and temperate forest, open forest and woodland and scrub.

106. According to summary table 2, there was an estimated decrease in emissions of 43.418 Gg CO_2-e between 1990 and 1998, which is mainly due to a decrease in the above-ground data for all three categories of land attributed in the NIR to a decline of almost 300,000 ha per year in the national annual clearing rate. However, according to the NIR, only low confidence can be placed upon this trend estimate.

107. An analysis of the ratio of CO_2 emissions from above-ground to below-ground for the three categories: Closed tropical and temperate forest, open forest and woodland and scrub shows the following:

(a) All three categories show the same trend with the highest ratio in 1990, the lowest ratio in 1991 and a steady increase in the ratio from 1991 to 1998;

(b) The ratios are very similar the ranges being 1.18 to 0.61 for closed tropical and temperate forest, 1.23 to 0.75 for open forest and 1.03 to 0.60 for woodland and scrub.

108. An explanation about the trend described above would be very helpful. Australia informed the review team that the change in ratios over time is due to a combination of the decay rate assumptions and the changes in activity data over the period. The average annual clearing rates estimated for 81-90 are significantly higher than in the 91-95 period, as a large amount of the belowground carbon from land cleared in 1990 is released in 1991 there is a large drop in the ratio.

109. It is noted that re-growth associated with land clearing is included under sector 5.B according to the methodology used in Australia. Australia informed the review team that due to shading of the 5B removals column in the CRF tables the regrowth sink has been reported under 5E Others to ensure transparency and that the CRF tables for the 1999 Inventory have been modified to allow reporting of these removals under 5B.

110. *Consistency*: See para. 97 above.

111. *Recalculations*: The NIR describes several changes in the methodology, which did not induce major effects on data. The quantitative effects of recalculations have been provided.

112. *Transparency*: There is enough information on both methodological issues and indicators (emission and conversion factors and activity data). Additional information explaining the choice of categories, methods, indicators and emission/conversion factors would be welcome. Australia informed the review team that explanation of the methodologies etc. is included in the Workbook for CO_2 from the Biosphere 4.2.

113. The inventory was partially carried out using country-specific methods and emission and conversion factors. However, detailed information was provided in the worksheets which enables Australia's inventory to be compared with those of other Parties. As completeness and transparency increase, better comparability can be achieved.

114. *Emission and conversion factors*: The following information has been taken from worksheets included in appendix table 5 of the NIR for the LUCF sector:

Category	**Biomass before conversion** (t dm/ha)	**On-site burning Fraction of biomass burned on-site**	**On-site burning Fraction of biomass oxidized on-site**	**On-site burning Carbon fraction of above-ground biomass burned on-site**
Closed tropical and temperate forest	213-235	0.85-0.88	0.9	0.5
Open forest	88-90	0.88-0.89	0.9	0.5
Woodland and scrub	46-51	0.88-0.89	0.9	0.5

On-site burning of forests:

	CH_4	**CO**	**N_2O**	**NO_X**
Trace gas emission ratios (e.g.: kt C_{CO2}/kt C_{CH4})	0.010	0.100	0.007	0.100

Category	**Off-site burning Fraction of biomass burnt off-site**	**Off-site burning Fraction of biomass oxidized off-site**	**Off-site burning Carbon fraction of above-ground biomass burnt off-site**
Closed tropical and temperate forest	0.02-0.05	1.0	0.5
Open forest	0.01-0.02	1.0	0.5
Woodland and scrub	0.01-0.02	1.0	0.5

Category	**C released by decay of biomass Biomass before conversion** (t dm/ha)	**C released by decay of biomass Fraction left to decay**	**C released by decay of biomass Carbon fraction of above-ground biomass**
Closed tropical and temperate forest	215-224	0.1	0.5
Open forest	88-89	0.1	0.5
Woodland and scrub	45-48	0.1	0.5

Category	**C released from below ground Below-ground carbon before clearing (t C/ha)**
Closed tropical and temperate forest	144-145
Open forest	95
Woodland and scrub	75

115. The above factors compare well with those in the literature. However, it is noted that the factors for the base year 1990 are sometimes on the extreme end of the range indicated. Any

additional background information to explain the ranges for the indicators above is welcome. Australia informed the review team that the ranges occur because the values presented in the tables are weighted averages. The methodology is compiled on a State and Territory basis as the biomass and burning practices differ between regions.

116. *Activity data*: Activity data for area converted annually have been provided for forest and grassland conversion in sheets 1 and 4 of worksheet 5-2 of appendix table 5 in the NIR related to LUCF.

117. A further explanation on the relationship of both data sets would be welcome as well as a reference to the origin of the data and a short description of the methodology used to estimate them. Australia informed the review team that the information is contained in the methodology workbook and LUCF supplementary report .

Category	Area converted annually (kha)
Closed tropical and temperate forest	7.0/15.0 – 17.7/18.5
Open forest	56.1/78.1 – 105.5/90.6
Woodland and scrub	271.5/387.8 – 551.6/441.4

118. The data on the upper end of the range refer to 1990. It would help verification if larger areas (e.g., larger than 100 ha) of land use and land-use change were identified with the help of a map. Australia informed the review team that current methodology is not done using a GIS system nor are all data from satellite imagery, so it is not possible to produce such a map. Australia is producing a National Carbon Accounting System which will allow greater spatial reporting of these emissions in the future. This system will be supported by detailed satellite imagery.

2.3 Abandonment of managed lands (table 5.C)

119. *Completeness*: Emissions are reported as Not Applicable for this source category. Again, the four categories as included in the IPCC guidelines, were qualified as NA. Further explanation would be helpful. Australia informed the review team that IPCC methodology states that only lands regrowing towards a natural state should be included in the inventory. In line with the IPCC guidelines *5.C Abandonment of managed lands* is considered to be Not Applicable because abandoned lands in Australia are generally degraded due to problems of salinity, hence regrowth is negligible. This issue is discussed in the methodology Workbook 4.2.

2.4 CO_2 emissions and removals from soil (table 5.D)

120. *Completeness*: Data have also been provided for category 5.D. Again, it is noted that the data do not relate to the soil types as specified by the IPCC guidelines but to the category "Other". The other category was specified as "Pasture improvement and minimum tillage". Again, an explanation related to the qualification NA would be helpful.

121. For the category the same amount of CO_2 removals was reported each year from 1990 to 1998, as: -4,224.0 Gg CO_2 per year. Australia informed that this estimate is highly uncertain and relies on limited data. Data to modify this estimate are not available. The emissions from

this source category are currently being reviewed through Australia's National Carbon Accounting System.

122. *Methodology*: Australia employs a country-specific method for CO_2 estimation.

123. *Emission and conversion factors*: The following information has been taken from the worksheets included in appendix table 5 of the NIR for the LUCF sector:

Category	Average increase in area of minimum tillage over 25 years (kha/y)	Average increase in area of pasture over 25 years other than associated with forest and grassland conversion (kha/y)	Average increase in soil carbon in inventory year per hectare*) (kt C/y ha)
CO_2 Uptake from	129	59	
A) Pasture improvement			A) 7.5
B) minimum tillage			B) 3.125

* This indicator has been calculated on the basis of column C of worksheet 5-4 of appendix table 5 of the NIR for the LUCFsector. Additional background information to explain the indicators above would add transparency. Australia informed the review team that additional information is included in workbook 4.2.

124. *Activity data*: according to worksheet 5-4 of appendix table 5 of the NIR, the average increase in area of minimum tillage is 129 kha/y and the average increase in area of pasture improvement is 59 kha/y. These values are averages over 25 years.

125. Additional information on the origins of the data and the method used to estimate them would improve transparency. Australia informed the ERT that additional information is included in workbook 4.2.

2.5 Other (table 5.E)

126. Additional removals and emissions have been reported under section 5.E for "Regrowth associated with land clearing" and "Prescribed burning of forests and wildfire" respectively. Under "Regrowth associated with land clearing", the same categories have been included as under section 5.B. Whereas under section 5.B the emissions are included, section 5.E addresses the removals associated with land clearing. Australia informed the review team that this is because the CRF table does not allow reporting of removals under 5B, it indicates the removals should be reported under 5D which is inappropriate. To ensure transparency the removals were reported under 5E. The CRF table for 1999 inventory has been modified to allow reporting of the regrowth removals under 5B. It is noted that the emissions from land clearing are 5.6 times (in 1990) to about 4.5 times (from 1994 to 1998) greater compared with the removal.

127. Country-specific EFs for emissions from wildfires for CO_2, CH_4 and N_2O, NMVOC and CO have been provided in the worksheets included in appendix table 5 of the NIR for the LUCF sector. The documentation does not specify the appropriate units to facilitate comparison. Based on appendix table 5 of the NIR, prescribed burning of forests is reported for a mass between 3,876 Gg and 4066 Gg, and wildfires is reported for a mass between 11,221 Gg and 14,165Gg. Additional information on the origins of the data and the method used to estimate them would be welcome. Australia informed the review team that Workbook Non CO_2 Emissions from the Biosphere 5.1 describes the methodology and emission factors.

3. Uncertainties

128. Uncertainty is described in a semi-quantitative manner, the classes being low (uncertainty of 20 per cent or less), medium (uncertainty between 20 and 60 per cent) and high (greater than 60 per cent). Of 19 parameters assessed, the uncertainty is high for ten, medium for 7 and low for only two (carbon fraction above ground and area of plantations). A modified version of the IPCC methodology has been used to assess uncertainty. A project should help to improve the estimation of uncertainty. Australia informed the review team that the methodology for LUCF is being significantly revised through the National Carbon Accounting System to address these high levels of uncertainty.

4. Reporting

129. The NIR includes a lot of very relevant information for the review process and helps to clarify the underlying calculations. However, it frequently refers to methodological workbooks published in previous years. Australia informed the review team that these methodology supplements are provided to the secretariat together with the annual inventories. The fact that the NIR includes elements of an inventory improvement programme and addresses quality control issues was appreciated by the review team.

5. Areas for improvements

130. The following areas should be included: Further information on the character of land being converted (see sector 5B; managed or unmanaged land), urban soils, non-forest soils and further additional information as identified above.

F. WASTE

1. General overview

131. Emissions from solid waste disposal systems (SWDS) were a dominant source of methane for this category, accounting for 91 per cent of total emissions from the waste sector, and making SWDS a key source category. Country specific methodologies were used in all cases and the NIR contains details on these as well as on trends and uncertainties.

2. Completeness

Key source: Solid waste disposal on land

132. The CRF indicated the method as Australian Methodology Workbook. However, table summary 3s2 reported the methodology as tier 2, using a model for the emission estimates. Since the IPCC guidelines have no tiers for waste, the designation of tier 2 was used to indicate that the method is not a default approach and is closer to FOD.

Non- key source: Wastewater handling

133. The CRF reported only methane emissions and did not take N_2O into account. Table 9s1 indicated that a methodology for this has not yet been developed. However, the IPCC guidelines

do present an equation (Eq 15) for calculating N_2O from sewage, albeit with a large uncertainty associated with it. The issue should be reconsidered when appropriate.

Non-key source : Waste incineration

134. The CRF includes reporting of CO_2 from 1995 onwards. Calculation of CH_4 and N_2O are omitted and no additional information is provided in table 9s1. It appears that the discontinuity in the CO_2 estimate is due to lack of data but some discussion would assist reviewers interpret this phenomenon.

3. Methodologies

135. The methodology used was described in the Australian Methodology Workbook 8.1.

Key source: Solid waste disposal on land

136. High rate of waste generation of 2.18 kg/capita/day compared to IPCC guidelines value (1.26 kg/capita/day). An analysis compiled by the Australian Bureau of Industry Economics and Maunsell in 1994 established the national per capita MSW generation of 2.06 kg/capita/day. Subsequent MSW per capita generation has been estimated based on an annual growth rate of 0.73 per cent.

137. An explanation of DOC is needed.

138. The amount of gross annual methane generation (Gg of methane) from appendix table 6 (worksheet 6-1) was calculated from the potential methane generation rate per unit of waste, in units of litres CH_4/kg MSW. The factor used to convert from volume to mass of methane is 0.672 kg per cubic metre.

139. According to the CRF, waste generated is calculated at 41,095 kg/1000capita/day or 14,999.7 kg/year while annual MSW in SWDS is 11,925 Gg (25 year average).

Non- key source: Wastewater handling

140. Although methane emission and NMVOC emissions were estimated, N_2O was omitted.

141. The additional information for table 6B reported emissions from industrial wastewater handling as NE; however the estimates are presented in table 6B. An explanation of the methodology is recommended.

142. Methane recovery from domestic wastewater handling was higher than industrial wastewater handling. Additional information should be provided.

Non-key source: Waste incineration

143. CO_2 emissions were reported from solvent use as a result of waste incineration.

4. Emission factor

Key source: Solid waste disposal on land

144. Because Australia uses a tier 2 method in conjunction with country specific approach, some important parameters cannot be tracked. However, the emission factor appears to be in applicable limits according to the IPCC good practice guidance.

Non-key source : Waste incineration

145. The implied emission factor of solvent is at applicable limit.

5. Activity data

146. The activity data on table 6B of wastewater handling (based on COD and BOD) were described as NE, however there were estimates of methane removal and emission.

6. Uncertainties

147. The level of confidence is reported as 50 per cent uncertainty.

7. Trends

148. Emission: Trends of CO_2 equivalent increased slightly from 1990-1998. Emissions of CH_4 per capita declined slightly from 1990-1998 (-3.6 per cent) but remained rather constant in wastewater handling (1.1 per cent incremental increase) due to population growth.

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