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REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF THE UNITED STATES OF AMERICA SUBMITTED IN THE YEAR 2000[1]

(In-country review)

EXECUTIVE SUMMARY

1. Institutional arrangements

1. While the institutional arrangements are quite complex, collaboration between the various agencies and organizations involved in developing the United States greenhouse gas (GHG) inventory, under the leadership of the U.S. Environmental Protection Agency (EPA), is functional and efficient.

2. Record-keeping

2. Reviewers were provided with a spreadsheet organization scheme and access to the modules. The USA is investigating switching to a database system. The review team had free access to the hard copy archives which provided many of the references needed for the review. Part of EPA's Quality Assurance/Quality Control (QA/QC) plan is to extend archiving provisions, which would provide linkages to provisions for logging expert judgements and to maintain an official track record of changes.

3. Transparency, completeness and consistency of reporting

3. Methods and rationale for selecting information sources, methods and emission factors were adequately described in the inventory. Some transparency is lost when the method is more complex or the chosen model requires a more disaggregated database.

4. In addition to Table 9 of the Common Reporting Format (CRF) on completeness, the National Greenhouse Gas Inventory Report (NIR) provides for a list of sources excluded from the inventory. The CRF and the NIR are consistent, except for a few differences resulting from the mapping of country-specific methodologies onto standard CRF tables. Total emissions estimates are not affected.

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

5. The USA generally followed the detail of Intergovernmental Panel on Climate Change (IPCC) and UNFCCC guidelines and provided a largely transparent inventory if both the NIR and the sources referenced in it are taken into account. The NIR alone does not fully represent the volume of work undertaken. The government's experts who were met during the review were very open and cooperative in addressing questions and information requests from the review team.

4. Summary of findings for each sector

4.1. Energy

6. Ten of the 17 key sources of the inventory are energy related. The Energy Information Administration (EIA) of the Department of Energy (DOE) provides fuel production and consumption data for all energy related activities, and also develops its own GHG emissions inventory which allows for some degree of verification. The United States' inventory and international data on energy related CO_2 agree to within about 1 to 2 per cent. Sources excluded from the energy sector estimates are identified in the NIR and the CRF but explanations could be more informative. Since there are no agreed international methodologies for the excluded sources, the coverage of the inventory is functionally complete.

7. There exists an extensive empirical basis for the emission factors for gaseous and liquid petroleum fuels, used for deriving both the mobile and stationary emissions estimates. For the latter, an interesting comparison of estimates for the power generation with continuous emissions monitoring, undertaken for the SO_2 trading programme shows national estimates are below measured emissions by roughly 7 per cent, a difference attributed to moisture effects and the type of sensors used. Work to improve understanding of balancing terms is under way at the EPA and the EIA, and will be used as a measure of the uncertainty in activity data.

8. As far as fugitive emissions from oil and gas are concerned, detailed component based emission factors are obtained by a method using drivers for both oil and gas The assumption that the venting to flaring ratio remains constant could be reviewed. The USA identified the need to update the census on numbers of oil tanks.

9. Decreasing fugitive CH_4 emissions from solid fuels by 26 per cent between 1990 and 1998 is due to a shift to surface mining especially in the less gassy western coal fields, plus increased recovery. The methodology is a mixture of empirical data and default assumptions. An assessment of the overall uncertainty would be useful to check statistical cancellation of measurement errors between mines.

10. N_2O emissions from transportation are an example of a public review leading to a revision of emissions estimates, through an EPA 1999 measurement campaign which produced revised emission factors for passenger cars as a function of catalyst age and gasoline sulphur content. The measurement campaign could be extended to other vehicle types including diesel vehicles, SUVs and goods vehicles, as well as to quantifying the effects of catalyst temperature.

11. With respect to bunkers, activity data and definitions are the main difficulties in estimating bunker emissions. The allocation issue needs to be resolved by the international community. Domestic aircraft emissions are calculated by subtracting of the international bunker estimates from the domestic total. Given the risks in estimating a category from the difference in other

categories, it would be worth considering an independent study of trends in domestic aviation, perhaps based on aircraft movement data.

4.2. Industrial Processes

12. The USA includes the CO_2 emissions from iron and steel production, ammonia manufacture, ferroalloy products and aluminium production in the energy sector estimate rather than under the industrial processes, as recommended by the IPCC guidelines. Proper reallocation is planned. The iron and steel key source should be estimated with the Good Practice Tier 2 methodology. Use and subsequent emissions of HFCs and PFCs as ozone depleting substances substitutes increased by a factor of 50 between 1990 and 1998. Uncertainty should be estimated for these sources. Confidentiality issues are well handled by using of a third party data collection system. Overall, methods used are in line with the IPCC guidelines. There exists an ongoing process for improvement that includes increasing collaboration with industry.

4.3. Solvents and Other Product Use

13. In the solvents and other product use categories, only the NMVOC emissions are included in the inventory. Inclusion of N_2O sources should be considered.

4.4. Agriculture

14. This sector includes four out of the 17 key sources. “Commercial organic fertilisers”, a country specific source, were included with the direct emissions of N_2O from agricultural soils. The methodology and assumptions made to estimate the nitrogen content of these fertilisers are discussed in the NIR.

15. The emissions of CH_4 from enteric fermentation from dairy cattle remained almost constant in spite of a decline in dairy cattle population, due to an increase in milk production. For these emissions, a mechanistic model of the rumen function was used. Future updates of the inventory will be carried out with the energy balance model suggested in the tier 2 approach of the 1996 IPCC guidelines.

16. Indirect emissions of N_2O from agricultural soils showed a small increase of 8 per cent in the period. Most of the difference is due to higher estimates of surface run-off and leaching. CH_4 emissions from manure management systems represent the fastest growing source in the sector, showing an increase of 52.7 per cent over 1990 to 1998. The change is due to a shift in the dairy and swine industries towards larger facilities more likely to use liquid manure management systems.

17. Change of methodology and improved cattle and swine population characterization already in practice imply a major recalculation of emissions in future updates for these four categories.

4.5. Land Use Change and Forestry

18. The large sink reported in the LUCF inventory is largely explained by forest sequestration including forest soils. The LUCF estimates are generally complete, with exceptions, and consistent with the IPCC guidelines. The CRF tables were used in a way that suits the United States’ national circumstances. Transparency would benefit from a more detailed

explanation of methodologies and models used. This could be provided in a LUCF annex to the NIR. Annual changes in forest stocks could be developed in the future following the introduction of a new forest inventory. Also, estimates of C stocks changes from land conversion and abandonment of managed lands could be provided. Various cross checks have been made on the estimates of forest C stocks including using CO_2 concentration measurements data. Based on expert judgement, the uncertainty of C flux estimates for the total forest was estimated to be 15 per cent. Estimates for forest soil carbon largely determine this uncertainty. The production method was used for harvested wood products stocks, which covers only the domestic harvest and excludes exports or imports. Given the availability of harvesting data, the reporting of annual stocks data would be desirable.

19. The inventory of non-forest soils carbon stocks under review has an incomplete time series of non-forest soil carbon stocks. The 1992 National Resources Inventory contained the most recent available data at the time of developing the inventory, and no projections had been used for 2000 to allow an extrapolation of mineral soils C stocks estimates. Work is under way to adapt the IPCC methodologies and factors to United States' conditions. The overall uncertainty in the current estimate was put tentatively at 20 to 25 per cent.

20. The USA is the only country accounting for carbon storage in landfilled yard trimmings (grass, leaves and branches). The need for better data on the quantity of yard trimmings disposed and a better understanding of the fate of lignin in landfills is recognized.

4.6. Waste

21. Landfills are the single largest anthropogenic source of methane in the USA. The inventory information is complete. The country specific model based approach is consistent with IPCC Good Practice. The EPA chose not to apply IPCC tier 2 methodology because of the many uncertainties in the variables. Recent and comprehensive CH_4 measurement data are lacking. The uncertainty in the methane emissions from this source is put at 30 per cent. Further surveys of flaring by industry associations should decrease the overall uncertainty. Work is also underway to estimate wastewater treatment CH_4 emissions from the largest industrial sources.

5. Verification and QA/QC procedures

22. While the NIR provides no specific information on verification procedures or QA/QC, it was discussed with the EPA and the EIA. The USA is in the process of developing a QA/QC plan in accordance with the IPCC Good Practice Guidance. A number of checks are already performed, such as routine QC checks, particularly on the energy sectors and agriculture, by both the contributing experts to the source category and the EPA coordinator at the final stage of the compilation of the sector inventory. Some government agencies such the EIA and United States Department of Agriculture (USDA) apply QA/QC procedures to their own statistics.

23. The United States' inventory has a unique annual public review process, which, while not required by the UNFCCC guidelines, helps ensure transparency. Useful feedback from this process had been taken into account when improving the inventory.

6. Recalculations

24. Recalculation tables were not provided in the CRF (reported NA) but summary information as to major revisions in methodologies and data was provided in the NIR.

7. Uncertainties

25. The NIR provides both quantitative and qualitative indications of uncertainties for emissions sources. These are based largely on expert judgement. Uncertainties have not so far been combined into an overall uncertainty estimate, though this is under consideration as part of the development of the QA/QC plan. A framework using Monte Carlo analysis is being developed for the elicitation by expert judgement of uncertainty ranges for activity data and emission factors which will be used to derive overall uncertainties.

8. Areas for further improvement

26. Most areas for improvement concern detailed implementation of the 1996 IPCC guidelines, in particular, efforts to apply QA/QC procedures to all sectors, including models and data collection efforts, interagency cooperation and outreach to industry. Some of these have already been implemented in the 1999 inventory. Others are in the implementation and planning stages. The areas for improvement for each sector are detailed in the report.

A. OVERVIEW

1. Introduction

27. By its decision 6/CP.5, the Conference of the Parties (COP) at its fifth session adopted guidelines for the technical review of GHG inventories from Parties included in Annex I to the Convention, hereafter referred to as the review guidelines, for a trial period covering the GHG inventory submissions for the years 2000 and 2001. The COP requested the secretariat to conduct individual reviews of greenhouse gas inventories for a limited number of Annex I Parties on a voluntary basis. In so doing, the secretariat was requested to use different approaches to individual reviews by coordinating desk reviews, centralized reviews and in-country reviews.

28. The United States of America volunteered for such an individual review, specifically for an in-country review. The review of the 2000 GHG inventory submission of the USA, the third such activity conducted according to decision 6/CP.5, took place from 21 to 25 May 2001 in Washington D.C. According to the 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. The members of the review team were: Mr. Anthony Olusegun Adegbulugbe (Nigeria), Ms Pascale Collas (Canada), Mr. Jim Penman (United Kingdom), Mr. Luis Gerardo Ruiz Suárez (Mexico), Mr. Michael Strogies (Germany), Mr. James Grabert (UNFCCC) and Mr. Stylianos Pesmajoglou (UNFCCC). Ms Collas and Mr. Ruiz Suárez were the lead-authors of this report.

29. Experts were allocated to work in different inventory sectors in accordance with their area of expertise. At the beginning of the review, the host country officials provided a general overview of the inventory preparation, institutional arrangements, data collection and management. Two groups met in parallel over the next two days. One group covered Energy, Industrial Processes and Waste while the other covered Agriculture and Land Use Change and Forestry. During those sessions, national inventory experts responsible for the respective sector clarified further the key issues related to inventory preparation after which there followed a

questions and answers session. Where answers could not be provided immediately, written answers were provided over the course of the week.

30. For all sectors, the preliminary findings identified in the synthesis and assessment report of GHG inventories submitted in 2000 (FCCC/WEB/2001/1), and the comments on this report provided by the USA, were addressed during the respective sessions. Additional information on these findings is provided in the corresponding sections of this report. In the synthesis and assessment report, the secretariat had considered, for each individual Party, those source categories that are key sources in terms of their absolute level of emissions, applying the tier 1 Level Assessment as described in the good practice guidance. With regard to categories, this had been performed at the level of detail recommended in that guidance.

2. Emissions profiles and trends

31. The United States' emission profile is similar to that of many other Annex I Parties, having a significant energy-related component dominated by CO_2 emissions. Emissions of CO_2 accounted for 81 per cent of all GHG emissions in 1998. CH_4 emissions were the next largest contributor (10 per cent), followed by N_2O (7 per cent), HFCs, PFCs and SF_6 (2 per cent). The largest contributor by source was energy accounting for 84 per cent, of which 25 per cent coming from transport. Emissions from agriculture, industrial processes and waste accounted for 8 per cent, 4 per cent and 4 per cent of total emissions, respectively.

32. Tables 1 and 2 below provide data on emission trends by gas and by sector. Emissions of CO_2, excluding the land-use change and forestry category, have increased by 11 per cent between 1990 and 1998, and CO_2 removals from LUCF have decreased by 33 per cent over the same period. Emissions of CH_4 and N_2O have also increased by 2 per cent and 10 per cent. The emissions of HFCs, PFCs and SF_6 jointly have increased 73 per cent since 1990, largely due to the160 per cent increase in HFCs. The fastest growing source of emissions was industrial processes (38 per cent) followed by agriculture (14 per cent) and transport (14 per cent).

Table 1 (Gg CO_2-equiv.)

	1990	1995	1996	1997	1998	change per cent, 1990-1998	Share of total GHG, 1998
Stationary combustion	3,449,576	3,603,955	3,739,382	3,797,158	3,799,845	10%	56%
Transport	1,469,178	1,592,903	1,639,466	1,651,008	1,675,489	14%	25%
Fugitive fuel	245,293	240,781	236,698	233,443	225,722	-8%	3%
Industrial processes	177,207	209,858	229,187	235,551	245,198	38%	4%
Agriculture	473,007	519,322	527,737	540,352	540,679	14%	8%
Waste	234,525	244,215	243,538	244,701	240,064	2%	4%
Total GHG	**6,048,786**	**6,411,034**	**6,616,008**	**6,702,213**	**6,726,997**	**11%**	**na**
LUCF CO_2	(1,160,000)	(776,659)	(774,725)	(774,083)	(773,019)	-33%	na

Table 2 (Gg CO_2-equiv.)

	1990	1995	1996	1997	1998	per cent change, 1990-1998	Share of total GHG (without LUCF), 1998
CO_2 Emissions/ Removals with LUCF	3,754,351	4,417,183	4,601,355	4,675,891	4,705,032	25%	na
CO_2 Emissions without LUCF	4,914,351	5,193,841	5,376,081	5,449,974	5,478,051	11%	81%
CH_4 Emissions	652,139	675,095	671,412	673,758	663,449	2%	10%
N_2O Emissions	396,853	435,713	445,592	448,910	437,721	10%	7%
HFCs	35,777	52,686	67,584	75,073	93,072	160%	1%
PFCs	22,899	17,032	18,673	17,831	18,041	-21%	0%
SF_6	26,767	36,667	36,667	36,667	36,663	37%	1%

3. Data sources

33. The expert review team (ERT) reviewed the NIR and the CRF tables for all years between 1990 and1998 submitted to the secretariat on 11 April 2000. During the in-country visit, the review team was provided with supporting documents, which are referenced at the end of this report. The review team also used the synthesis and assessment report (S&A report) prepared by the secretariat, and the response of the USA to issues raised in the S&A report.

4. General issues

4.1. Institutional arrangements

34. The U.S. Environmental Protection Agency (U.S. EPA) representatives gave a thorough presentation of the U.S. National System for GHG inventory to the reviewers which included institutional arrangements, process organigrams and data flow organigrams. Data flow organigrams were provided for each sector. This information is not included in the National Inventory Report.

35. The EPA is the lead agency responsible for the preparation of the United States Government UNFCCC submission in coordination with other agencies and departments, in particular, the DOE, USDA and Defense. Over the years it has developed a comprehensive network, as well as collaboration with other agencies that contribute data, including the U.S.Geological Survey, the Federal Highway Administration, the Department of Transportation and the Department of Commerce. Data are also received on a voluntary basis from academia and industry associations. Overall, while the institutional arrangements are quite complex, the reviewers felt that collaboration between the agencies and organizations involved is functional and efficient.

36. The reviewers were also provided with the inventory development process organigram and a typical time line for inventory preparation. It was noted that, in common with other countries, timing of input from the source categories is sometimes a problem. A remarkable feature of the United States' inventory is the extensive annual review process which consists of a joint expert and interagency review and a public review. These are addressed in section 4.3 with other QA/QC issues.

4.2. Record-keeping

37. The inventory is prepared by a number of agencies and experts and therefore has modules with separate data and document components which are maintained in a linked spreadsheet system with a central integration file. The reviewers were provided with a spreadsheet organization scheme and access to the various modules. The USA is investigating switching to a database system.

38. The CRF Tables are directly linked to the spreadsheet. The inventory report consists of integrated sections corresponding to each spreadsheet file. Every year, each module is sent out to experts for updating. Reference materials are submitted with each source category, document section and spreadsheet. Some reference material is available in electronic format and the EPA is building the electronic archives. Both hard and electronic archives are retained by the EPA and their contractors and are updated annually. The review team had free access to the hard copy archives which provided many of the references needed for the review, though further inquiries involving United States' experts were sometimes needed. The EPA plans to develop the archive, which could also be used for logging expert judgements.

39. Data archiving is likely to require a combination of central and plant level data storage. In the USA, case data are being archived at plant level where statutory requirements exist, for example linked to criteria pollutants or ozone depleting substances. Part of the EPA's QA/QC plan is to extend archiving provisions. An audit of data archiving associated with HFC 22 emissions from the production of HCFC-23 has been completed.

40. A method for maintaining an official track record of changes made to the spreadsheets is being developed as part of the QA/QC plan.

4.3. Transparency of reporting

Calculation sheets for activity data, emission factors in disaggregated manner

41. The ERT had free access to the calculation sheets used to assemble the inventory.

Description of methods and assumptions

42. In general, methods and the rationale for selecting information sources and emission factors were adequately described and documented in the spreadsheets. Some transparency is lost when the method is more complex or the chosen models require a more disaggregated database. In many cases the decision to re-aggregate data to correspond to the CRF inevitably requires some judgement, though this does not affect national totals.

Recalculations

43. Recalculation tables were not provided in the CRF (reported NA) but the NIR provided information as to major revisions in methodologies and data. Sometimes, where the summary did not provide full explanations, data were checked against the previous inventory report.

Verification and QA/QC procedures

44. The NIR provides no specific information on verification procedures or QA/QC but the reviewers discussed this with the EPA and the EIA. The USA is in the process of developing a

QA/QC plan in accordance with the IPCC Good Practice Guidance. A number of checks are already performed throughout the inventory preparation process and are described below.

45. The contributing source category experts perform routine QC checks, particularly in the energy and agricultural sectors, which have their own established QA/QC procedures, as described subsequently. Historical consistency (both revisions and trend) is then verified. The EPA inventory coordinator performs QC checks and reviews.

46. A separate GHG inventory prepared by the EIA allows the EPA and the EIA to conduct a mutual validation of the energy estimates and cross checks are possible through statistical balances and continuous emissions monitoring data in the power sector. For the waste sector, the EPA's tier 1 method for landfills and the EIA's tier 2 lead to very similar results.

47. The United States' inventory has a unique annual public review stage. This is not required by the UNFCCC reporting guidelines, but it helps ensure transparency. Following a Federal Register Notice, the public review draft is posted on the web site for 45 days for comments. About two dozen public comments were received on the draft 1998 inventory. If relevant and technical issues are raised, the person's name or organization is included for the following year's expert review. Feedback from this process has produced better estimates for N_2O emissions from transportation, and the National Lime Association provided useful suggestions for further work.

48. The EPA also noted that in the future a blind review by an academic or a suitably qualified independent organization would be worth considering.

49. The NIR and some of the main background papers are available on the web site, and the NIR has many conventional bibliographic references.

Uncertainties

50. The NIR provides both quantitative and qualitative indications of uncertainties for emissions sources. These are based largely on expert judgement. Uncertainties have not so far been combined into an overall uncertainty estimate, though this is under consideration as part of the development of the QA/QC plan. The USA is developing protocols for the elicitation by expert judgement of uncertainty ranges for activity data and emission factors. The ranges will be used to assess the overall uncertainties. The USA stressed the importance of achieving consistency when using expert judgement.

Confidentiality issues

51. Issues related to confidentiality were covered during the discussions on the energy and industrial processes sectors. Some data concerning the non-utility power producers are considered confidential and the EIA must follow established confidentiality procedures when handling and publishing them. Similarly, there are a number of sources under industrial processes that use confidential data. In these cases the EPA has established partnerships with industries or works with producers through industry and trade associations on a voluntary basis. In those instances, the third party (industry and trade associations) collects the relevant data, conducts the necessary validation procedures and provides the EPA with aggregated information.

4.4. Completeness and consistency of reporting

52. In addition to Table 9 of the CRF on completeness, the NIR provides for a list of sources excluded from the inventory. Examples include CH_4 from abandoned coal mines and from wetlands affected by human activities. Expert judgement is used to prioritize the work needed to include them. The CO_2 from non-forest soils is incomplete in the inventory under review, but is present as a complete time series in the 2001 inventory, making the inventory functionally complete and consistent with the 1996 revised IPCC guidelines.

53. The CRF and the NIR are consistent except for a few differences resulting from the mapping of country-specific methodologies onto standard CRF tables. Total emissions estimates are not affected. The CRF recalculation table was not provided and the CO_2 reference approach table is incomplete in the inventory under review, although the NIR provides details on recalculations and the reference approach data. The reasons for this are discussed below.

54. Minor inconsistencies and errors in the filling in of the CRF tables will be addressed in next year's inventory.

55. The United States generally followed the detail of IPCC and UNFCCC guidelines and provided a largely transparent inventory, taking into account both the NIR and the sources referenced in it. The NIR alone does not fully represent the volume of work undertaken. The review helped in gathering additional information. The government's experts who were met during the review were very open and cooperative in addressing questions and information requests from the review team.

5. Areas for further improvement

56. The key improvement will be the efforts undertaken to apply QA/QC procedures to all sectors. Other areas requiring improvement were identified during the review and are addressed for each specific sector in the sections below. Most relate to the detailed implementation of the 1996 IPCC guidelines. Some of these improvements have already been implemented in the 1999 inventory. Others are in the implementation or planning stage. They encompass models and data collection efforts, interagency cooperation and outreach to industry.

B. ENERGY SECTOR

1. General overview

1.1. Introduction

57. In 1990 the United States' total greenhouse gas emissions from the energy sector were estimated to be 5164 Tg CO_2 equivalent (or CO_2 equiv.). By 1998 energy sector emissions had increased by about 10.4 per cent to 5701 Tg CO_2 equiv. The energy sector accounts for about 85 per cent of total GHG emissions. CO_2 accounts for about 95 per cent of emissions from the energy sector. Ten out of the seventeen key sources identified by the UNFCCC secretariat are energy related.

1.2. Institutional arrangements

58. A memorandum of understanding exists between the EPA and the EIA of the DOE, whereby the EIA provides fuel production and consumption data for all energy related activities. A close working relationship has developed with the EIA for preparing the annual energy GHG estimates. The EIA is also mandated by the Energy Policy Act of 1992 to develop an annual national emissions inventory for all gases. A copy of its 2000 report was provided to the ERT.

1.3. Verification and QA/QC procedures

59. The NIR and the EIA inventories are complied independently but have much input data in common. Their inter-comparison therefore provides a validation cross check on the computational correctness of both inventories but does not amount to independent verification.

60. The EIA has established QC procedures for the surveys that produce the energy statistics used in the inventory. These include automated checks for consistency with recent survey returns. Survey QC requirements are set out in the EIA's annual data compilations for oil and gas supply and coal consumption. The EIA screens survey returns for completeness, compliance with reporting requirements and reasonableness. Respondents must refile any reports that fail the checking procedures

The ERT compared United States' and international estimates of CO_2 emissions from the energy sector:

Year	US inventory (energy sector CO_2)	US reference approach	IEA reference approach	IEA Sectoral approach	CDIAC
	$TgCO_2$	+/-%	+/-%	+/-%	+/-%
1990	4840.5		0.1	-0.3	-1.2
1991	4787.9		0.8	-0.2	-0.6
1992	4876.9		0.1	-0.8	-1.2
1993	4992.1		1.2	-0.3	-0.3
1994	5067.2		0.8	-0.2	0.4
1995	5103.8	0.0	0.4	-0.6	0.2
1996	5284.9	0.4	-0.4	-0.6	-0.6
1997	5355.9	1.1	2.1	1.0	
1998	5383.5	0.8	0.5	0.9	

61. The United States' inventory and international data on energy related CO_2 agree to within about 1 or 2 per cent, subject to a small adjustment up or down depending on which emissions are counted under industrial processes (see section C.2. for a discussion of this). This agreement is as expected for a coherent inventory. The alternative approaches make greater use of default values and are therefore less accurate than the inventory itself, but they provide an overall check that the results are reasonable. Use of continuous emissions monitoring to verify power sector estimates is discussed below.

1.4. Completeness

62. The NIR and the CRF clearly identify sources excluded from the energy sector estimates. There are no agreed international methodologies for the excluded sources. Coverage of the inventory is therefore functionally complete. The CRF explanations about the excluded sources could be more informative, perhaps with cross-references to the more detailed background material in the NIR. The sources themselves should be kept under review for future inclusion as agreed methodologies develop, particularly those associated with CO_2 from burning coal deposits and waste piles, CH_4 from abandoned mines, fugitive CO_2 emissions associated with oil and gas production, and enhanced oil recovery. The USA said that it was aware that some countries were currently reporting on fugitive CO_2 and that it was considering suitable methodologies for future inventories and including this source as well as CH_4 from abandoned mines.

1.5. Transparency

63. The NIR annexes provided accessible technical summaries of methods used, plus extensive references to background documentation, much of which would be too bulky to include in the NIR. The EPA maintains a paper archive of this material and some of it is available on the internet. The ERT made use of the archive material as indicated in the reference section of this report.

1.6. Uncertainties

64. The NIR provides quantitative estimates or qualitative discussions of uncertainties for each source but no overall uncertainty estimate has been made. As part of the QA/QC plan mentioned in section 4.3 above, the USA is developing protocols for the elicitation by expert judgement of uncertainty ranges for activity data and emission factors. These ranges will be used to assess overall uncertainties. The USA stressed the importance of achieving consistency when using expert judgements. For power generation, quantitative comparisons have been made between emissions estimates derived from fuel consumption and those from continuous emissions monitors; some checks have been carried out between refinery output and road transport fuel sales; and statistical balancing terms are published for oil, gas and coal.

1.7. Recalculations

65. Because of recalculations affecting the historical time series, United States' emissions from the energy sector increased by an estimated 9.95 per cent between 1990 and 1997 according to the previous inventory, and by 10.02 per cent according to the inventory under review. Pages 1.17 to 1.21 of the NIR describe changes in data and methodologies which affect the energy sector. The most significant of these occur in transportation (inventory under review lower than the previous one by 19.8 and 11.4 Tg CO_2 equiv./yr. in 1990 and 1997 respectively) and fugitive emissions from petroleum systems (inventory under review higher than the previous one by 21.3 and 18.0 Tg CO_2 equiv./yr. in 1990 and 1997 respectively). The transportation change is due most importantly to more detailed coverage of military bunker fuels, and the petroleum systems change follows the introduction of more disaggregated study emissions from this source.

2. Consistency with the IPCC guidelines and the UNFCCC reporting guidelines

66. The methodologies examined were consistent with IPCC guidelines and the CRF except that disaggregation by industrial sector is not provided in Table 1 of the sectoral report for energy. The USA explained that this is because the relevant data were not available on an annual basis. However a periodic survey (the Manufacturing Energy Consumption Survey, MECS) disaggregates energy data to the 4 digit industrial classification and provides the basis for this information. The USA uses original units fairly extensively in the NIR; although this helps with cross referencing source material it can make the review process more difficult and it would be useful if key tables, such as carbon contents of fuels, also had columns in the units used by the IPCC.

3. Reference Approach

67. The USA had reported reference approach calculations in the NIR but not in the CRF, because of difficulties with the CRF spreadsheet. The review process identified data on carbon stored in products as the probable cause and these were found to have been entered in the CRF spreadsheet (but not in the NIR calculations) on a full molecular weight rather than a carbon basis. The USA provided new CRF calculations which agree with the reference approach in the NIR to within 0.1 per cent.

4. Feedstocks

68. The data in the 1998 NIR uses the IPCC tier I method for assessing emissions and storage of carbon from fuels used as feedstocks. Storage coefficients are more detailed than the IPCC defaults, but generally consistent with them. An apparent discrepancy in the value for natural gas as a feedstock (IPCC default 33 per cent storage, NIR value 100 per cent) is explained because purely emissive feedstock uses of natural gas are accounted for separately. Separate analysis by the EPA suggests that carbon stored in products could be about 10 per cent more than currently assumed (equivalent to about 33 Tg CO_2 equiv./yr. or about 0.6 per cent of energy emissions), and that storage in lubricants and petrochemical products is currently over- and under-estimated respectively. Future inventories will be revised accordingly, although all these estimates rely heavily on expert judgement. The EPA is sponsoring work with the industries concerned to improve the basis for these estimates by analysis of the mass balances in the processes involved.

5. Key sources

5.1. Mobile combustion – road vehicles – CO_2 emissions

Trends

69. Between 1990 and 1998 total emissions are estimated to have risen 15.5 per cent (1122 to 1294 Tg CO_2 equiv./yr.), with about 70 per cent of the increase due to emissions from cars and light trucks.

Methodologies

70. Emissions are calculated from fuel supplied by refineries multiplied by carbon content. The USA said that some work that has been undertaken, at the state level to compare sales data with supplies, suggests agreement to within about 5 per cent. This is a useful cross check and

helps build confidence in the vehicle miles travelled (VMT) data used for estimating some non-CO_2 gases, but top-down estimates are likely to be more accurate.

Activity data

71. Fuel supply data come from refineries via monthly survey forms from the EIA and are cross checked against fuel tax receipts. This information is simple to interpret for gasoline, which is only used for road transport. Diesel is also used for stationary combustion, so Federal Highway Administration data on VMT by vehicle type is used to make the disaggregation. This comes from vehicle sales, automated vehicle counts, and travel surveys.

Emission factors

72. Table A-13 of the NIR contains time series for motor gasoline and jet fuel whose annual average carbon contents have varied historically. The ERT was told that this was due to the phasing out of leaded gas, the introduction of oxygenates, and the changing balance of jet fuel components. The generic gasoline and jet fuel carbon contents vary because the mix of components falling within the generic class varies over time. Underlying carbon contents of the components within the class are from empirical analyses conducted between 1929 and 1993. An overview of this very detailed work and a list of references can be found on pp. 78-92 of *Emissions of Greenhouse Gases in the United States 1987-1992* (EIA 1994).

5.2. Stationary combustion – gas, oil, coal – CO_2 emissions

Trends

73. Total emissions from stationary combustion increased by 10 per cent between 1990 and 1998. Power generation on its own rose by 11 per cent (1749 to 2017 Tg CO_2 equiv./yr.). When emissions from power generation are allocated to end-users, residential emissions increased by 13 per cent (928 to 1052 Tg CO_2 equiv./yr.), commerce by 16 per cent (759 to 876 Tg CO_2 equiv./yr.), and industry by 6 per cent (1657 to 1756 Tg CO_2 equiv./yr.).

Methodologies

74. Emissions are estimated using the IPCC procedures with nationally determined emission factors. A comparison with continuous emissions monitoring (CEM) is possible for the power generation sector because of sensors installed in connection with the sulphur trading programme. CEM values are found to be roughly 7 per cent above fuel based estimates with very close agreement on year to year differences. United States’ experts believe that most of this difference is due to moisture effects which will be eliminated with the new generation of CEM technology. This is important work in inventory verification because activity data, being the result of survey returns rather than laboratory analysis, are more difficult to cross check than emission factors.

Activity data

75. Monthly surveys of activity data for oil, gas and coal are obtained from fuel suppliers and power generators by the EIA under statutory powers. The EIA also publishes statistical balancing terms derived from these surveys in the *Monthly Energy Review* and the *Quarterly Coal Report*. Balancing terms show the difference between supply and consumption estimates and are, at least in principle, a measure of uncertainty in activity data. The difference is usually less than 3 per cent for oil and gas and 2 per cent for coal. The gas term can be up to 6 per cent. It is usually

negative indicating that apparent consumption (i.e. production + imports – exports - stock change) exceed reported consumption (e.g. consumption metering), but small positive values have occurred. The ERT felt that statistically this could be due to an offset of about 3 per cent (possibly to avoid underselling) in combination with a random term of about the same magnitude. The ERT noted that work to improve understanding of balancing terms is underway in both the EPA and the EIA.

Emission factors

76. Table A.13 of the NIR publishes time series for residential, commercial, industrial and utility coal. Carbon contents for these generic coal types vary slightly because of a variation in the mix of underlying coals. The annual variation is derived from empirical data on the relationship between coal rank, heat content and carbon content by state or origin as set out in Appendix A of EIA's *Emissions of Greenhouse Gases in the United States 1987-1992*, which also describes the extensive empirical basis for the emission factors for gaseous and liquid petroleum fuels, as referred to in the previous section.

5.3. Fugitive emissions from oil and gas

Trends

77. There was an overall drop in emissions estimates of 1.3 per cent between 1990 and 1998, made up of an increase of 1.6 per cent (121 to 123.2 Tg CO_2 equiv.) for gas and a decrease of 14.4 per cent (27.1 Tg CO_2 equiv. to 23.1 Tg CO_2 equiv.) for fugitive emissions from oil.

Methodologies

78. For the gas industry, the Gas Research Institute (GRI) has established detailed component based emission factors based on a combination of *in-situ* measurements on individual components using a high flow sampler, pressure decay tests on pipelines and atmospheric tracer gas measurements. These values were also used as the basis for a study of emissions in the petroleum industry by the consultancy firm ICF for the EPA. These two studies fixed emissions in 1992. Values in other years were then estimated using drivers – for gas these were number of wells, miles of transmission pipeline, miles of distribution pipeline and miles of distribution services. For oil, the drivers were refinery feed or production, number of wells, amounts of crude and miles of pipeline. This work is much more detailed than the previous estimation methodology. The method using drivers will give correct results, provided characterization of component types is sufficiently detailed to capture technological improvements over time. Otherwise it could eventually overestimate future emissions.

79. The EIA totals for venting and flaring from survey data are disaggregated by the EPA using a ratio derived from the GRI study. This assumes that the venting to flaring ratio remains constant. The ERT team felt that this assumption and the basis for the venting and flaring estimates could usefully be reviewed. The USA identified the need to update the census on numbers of oil tanks.

5.4. Fugitive emissions from solid fuels

Trends

80. Fugitive CH_4 emissions are estimated to have fallen 26 per cent between 1990 and 1998 (from 88 to 65.3 Tg CO_2 equiv/year), despite a 9 per cent increase in coal production. This is due to a shift to surface mining, especially in less gassy western coal fields, plus increased recovery.

Methodologies

81. Underground mines accounted for about 64 per cent of emissions in 1998. Methane in ventilation air is measured at all deep mines at least quarterly for health and safety reasons by the Mine Health and Safety Administration. Twenty mines have degasification systems, of which 14 recover and use or sell methane. Recovery and other degasification data are obtained from operators or state authorities, or else estimated on the assumption that degasification accounts for 40 per cent of methane liberated. Surface mine estimates are from *in-situ* CH_4 content, which has been measured by basin, multiplied by 2, the mid-point of the range recommended by the IPCC to account for migration. Post mining is assumed to account for an additional 32 per cent of *in-situ* content, also on IPCC advice. For all years but 1997, mines emitting more than 0.1 or 0.5 mscfd (million standard cubic foot per day) were measured for methane in the ventilation air. In 1997, all mines were measured and EPA was able to calculate an adjustment factor to apply to the other years.

82. The methodology is therefore a mixture of empirical data (covering ventilation measurements, *in-situ* contents, amounts recovered, coal production) and default assumptions (covering the rest). The uncertainty in the ventilation component has been estimated at between 10 and 20 per cent at each mine, however, assuming no systematic bias exists in the observations, the overall uncertainty in this part of the estimate will be reduced because of statistical cancellation of errors between mines. It would be useful to make this overall assessment. The empirical basis for *in-situ* methane content by basin is given on page 41 of *Methane Emissions from Coal Mining*, EPA 1990. The methodology probably makes best use of the data currently available. However, *in-situ* contents for the less gassy western coal fields are less well measured than those in the East and it might be worth reviewing the case for some additional measurements to confirm the *in-situ* contents being used, given that these data are the basis for the declining trend in emissions.

5.5. Transportation N_2O

Trends

83. Emissions from this source increased 25 per cent between 1990 and 1998, from 50.6 to 63 Tg CO_2 equiv.

Methodologies

84. The USA uses the IPCC methodology with nationally determined emission factors. This is an example of public review leading to revision of emissions estimates; a question raised at the public review stage of the 1998 inventory was referred to the technical review panel, leading to a measurement campaign by the EPA in 1999 which produced revised emission factors for passenger cars as a function of catalyst age and gasoline sulphur content. The ERT felt that this

was an excellent example of how transparency and a national public review process can work together and hoped that the measurement campaign would be extended to cover other vehicle types including diesels, SUVs and goods vehicles, as well as the dependency of emissions on catalyst temperature.

Activity data

85. Fuel consumption by vehicle type is derived from the EPA's Mobile 5a model with Department of Transportation and EIA statistics as inputs.

Emission factors

86. Nationally determined values are used, as described under Methodologies. Types for which new factors have not been determined are scaled on fuel consumption, starting from the nationally determined values in the case of gasoline vehicles, or from European values in the case of diesel vehicles.

5.6. Bunkers

Trends

87. There was an estimated drop of 2.8 per cent in CO_2 emissions from international marine and aviation bunker fuels between 1990 and 1998. This was made up of an increase of 22.2 per cent in international aviation (up from 46.6 to 56.8 Tg CO_2 equiv./yr) and a fall of 18.5 per cent in marine fuel (down 71.1 to 57.9 Tg CO_2 equiv./yr). Non-CO_2 gases account for an estimated 0.95 per cent of the total.

Methodologies

88. The assumptions are set out under activity data below. Treatment of military marine and aviation emissions is not defined in the IPCC guidelines. The United States' underlying assumption is that for inventory reporting under UNFCCC, definitions should be the same as for corresponding civil activities. The USA does not separate cruise and LTO emissions for non-CO_2 gases.

89. Domestic emissions are calculated in the case of the USA by subtraction of the international bunker estimate from the domestic total. NIR Table ES-4 suggests that this process led to an increase in emissions from domestic aircraft by 2.5 per cent between 1990 and 1998 (from 176.7 to 181.1 Tg CO_2 equiv./yr). This seems modest, given the international increase of over 22 per cent. However, the Table ES-4 data contain military consumption as well as some non-aviation uses of jet fuel, and the increase in domestic aviation, as measured by commercial air carriers only (NIR table 2-8) was more like 11 per cent between 1990 and 1998, roughly half the international percentage increase. This clarifies the data in ES-4, but given the risks in estimating a category from the difference in other categories, the ERT felt that it would be worth considering an independent study of trends in domestic aviation, perhaps based on aircraft movement data.

Activity data

90. The United States Bureau of Transportation provides aviation fuel data for international flights by United States' carriers. This data include aircraft-mile data, flight data and fuel purchase records. Half of this fuel is assumed to have been purchased in the USA. Flights to Canada and Mexico are counted as domestic, and those to United States' territories overseas as

international. Fuel used by US flag carriers is added to fuel used by non-US flag carriers (all of which are assumed to be on international flights), which is estimated from expenditure data (US Bureau of Economic Analysis) and fuel prices. The US Department of Commerce provides data on fuel sales to vessels departing United States' ports for international destinations. The Department of Defense provides data for military aviation, and this is probably the best characterized part of the international bunkers estimate, since operational data allow assessment of whether the flight is to a domestic or an overseas destination. There is special treatment for naval vessels (all emissions at sea international; all emissions in port domestic).

Emission factors

91. CO_2 emission factors are from the EIA on the basis of fuel type data from the DOD and using the empirical basis already described under CO_2 from other mobile sources. IPCC defaults for Non-CO_2 gases are not separated into LTO and cruise altitude components.

Results from previous review stages and responses

92. The correction provided by the USA on marine bunker activity data, brings the corresponding international implied emission factors(IEF) into the expected range. The difference between marine bunker emissions reported by the International Energy Agency (IEA) and the NIR was discussed; the United States' submission to the IEA was consistent with the NIR value of 114.7 Tg CO_2. The IEA value is about 13 per cent higher, but the reason for the adjustment is unclear.

6. Non-key sources

93. The ERT briefly discussed other non-CO_2 emissions from mobile and stationary sources, most significant of which are methane from gasoline fuelled vehicles and methane from residential and industrial wood combustion, where IPCC methodologies are used. Together these declined by about 5 per cent between 1990 and 1998 – from 13.9 to 13.2 Tg CO_2 equiv/yr.
A potentially more significant issue concerns domestic aviation emissions where the treatment of international bunkers may be producing a trend that is increasing too slowly in the inventory.

7. Areas for further improvements

94. These are the main suggestions from the review of the energy sector, in the order they appear in the text. Some are already in hand.

- Consider making the CRF explanations about the excluded sources more informative, perhaps with cross-references to the more detailed background material in the NIR.
- Keep excluded sources under review for possible future inclusion, as agreed methodologies develop.
- Provide recalculations for Table 8(a) of the CRF, perhaps with cross references to more detailed explanations in the NIR.
- Develop disaggregation of emissions by industrial sector using MECS survey data.

- Provide key tables such as carbon content of fuels with information in units used by the IPCC.
- Include reference approach in Table 1.A(c) in the CRF (necessary information already exists).
- Continue useful work on comparison between CEM data and fuel consumption, and interpretation of statistical balances.
- Review evidence on split between venting and flaring, and basis for updating the census on numbers of oil tanks.
- Review case for additional measurements to confirm the in-situ C contents being used.
- Review impact of assumptions about international bunkers on estimated emissions from domestic aviation. Consider an independent study of trends in domestic aviation, perhaps based on aircraft movement data.
- Extend measurement campaign on vehicle N_2O to cover diesels, SUVs and the effect of catalyst temperature.

C. INDUSTRIAL PROCESSES

1. General overview

95. This sector is responsible for about 6 per cent of United States' emissions released through a wide variety of non-energy related industrial activities and as by-products, and include two of the17 key sources identified by the UNFCCC secretariat. The sector accounts for 100 per cent of the emissions for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, but only about 3.3 per cent, 6.5 per cent and 0.2 per cent of the national total for CO_2, CH_4 and N_2O respectively.

96. Emissions from industrial processes increased by 22 per cent from 1990 to 1998. In 1998, they were dominated by CO_2 (51 per cent), HFC (26 per cent) and SF_6 (10 per cent).

Table 3 Trend analysis for industrial processes

Absolute Figures given in CO_2 equivalent (Gg); share and trends in %		1990	1998	Trend
National Total Emission (NT)		4888.8	5953.9	21.8
Thereof Industrial Processes (IP)	(abs)	295.5	359.7	21.7
	(share of NT)	6.0	6.0	-0.1
thereof CO_2	(abs)	172.7	181.9	5.3
	(share of total IP)	58.4	50.6	-13.5
thereof CH_4	(abs)	1.1	1.5	33.3
	(share of total IP)	0.4	0.4	9.5
thereof N_2O	(abs)	36.3	28.2	-22.2
	(share of total IP)	12.3	7.8	-36.1
thereof HFCs	(abs)	35.9	93.1	159.2
	(share of total IP)	12.2	25.9	112.9
thereof PFCs	(abs)	22.7	18.0	-21.0
	(share of total IP)	7.7	5.0	-35.1
thereof SF_6	(abs)	26.8	36.7	37.0
	(share of total IP)	9.1	10.2	12.5

97. There are numerous institutional arrangements – mostly voluntary – to obtain the data needed to estimate emissions. These arrangements include official authorities (like the EIA, DOE and the USGS, Bureau of the Census), industry associations (like the Chemical Manufacturers Association), and Industry groups (like the Freedonia Group Inc.). Further input comes from the industry, trade groups, industry journals and academic literature.

98. Emission figures for a number of industrial processes are also published in the 1999 EIA report on greenhouse gas emissions in the USA. They use more or less the same sources as for activity data, but the results differ slightly. Mostly because of small inconsistencies in the activity data and slightly simplified methodologies used by the EIA.

99. To provide a clearer understanding of the importance for this sector of the industrial processes, CO_2 emissions are considered in this chapter, although the USA currently reports the source categories using fossil fuels as feedstocks under the energy chapter.

2. Consistency with the IPCC guidelines and the UNFCCC reporting guidelines

100. The estimates are generally consistent, although due to country specific circumstances (availability of data for fuels used as feedstocks) the CO_2 emissions from iron and steel production, ammonia manufacture, ferroalloy products and aluminium production are counted within the energy sector rather than under industrial processes as recommended by the IPCC guidelines and good practices. The USA plans to reallocate these emissions to the industrial process sector on the basis of an improved feedstock analysis. The Good Practice Guidance has a more detailed method for iron and steel, which is a key source.

101. The NIR explanations are generally clear, although where original units are employed, it would help the review process if parallel reporting were provided in the units used by the IPCC. Recalculations are explained in the NIR, although not in the CRF recalculations table.

3. Key sources

3.1. Iron and steel

102. After a sharp drop in 1991 to 20 per cent below 1990 levels, emissions increased by 13 per cent to bring the 1998 level to about 8 per cent below that for 1990. CO_2 emissions are calculated by multiplying annual estimates of pig iron (including steel production) by the ratio of CO_2 emitted per unit product. The emission factor was taken from the revised 1996 IPCC guidelines.

103. Activity data were obtained from the U.S. Geological Survey's (USGS) Minerals Yearbook: Volume I - Metals and Minerals. Since this is a key source, the USA should adopt the Good Practice tier 2 methodology, which takes explicit account of the amount of reducing agent used. This would require more detailed feedstock analysis.

3.2. Substitution of ozone depleting substances

104. Use and subsequent emissions of HFCs and PFCs as ODS substitutes increased by a factor of about 50 between 1990 and 1998. The methodology for estimating emissions is in line with the IPCC guidelines. A detailed vintage model of ODS-containing equipment and products is used to

estimate the actual and potential emissions of various ODS substitutes, including the HFCs and PFCs. The model combines a "bottom up" and a "top down" methodology. In the "top down" part HFC and HCFC production figures, as far as available, are used to calibrate the "bottom up" approach (including consideration of the equipment characteristics such as leak rates, charge size and expected lifetime). Information about the market development and expected technological changes are also included in the model.

105. Several different data sources were used including the ODS tracking system maintained by the EPA, UNEP TOC reports, reports by industry consortiums (like the AFEAS, which was provided as an example to the review team) and results of joint EPA/industry conferences on ozone protection technologies (Earth Technologies Forum). Further input comes from the EPA's collaboration with various trade organizations and individual companies. Emission factors used so far are country specific. Further improvement of the model depends on the availability of annual production data, which are very often confidential at the necessary level of detail. Reasons for uncertainties are identified but have not been quantified.

4. Non-key sources

4.1. Production of HCFC-22

106. HFC 23 emissions in 1998 were estimated to be 15 per cent above the 1990 level due to a 30 per cent increase in the production of HCFC-22. The different trends show the influence of implemented emission control technologies. The IPCC tier 2 methodology is used, based on data from plant-specific measurements provided cooperatively by the manufacturers of HCFC-22. To maintain confidentiality, manufacturers report emissions of HFC-23 to a third party, which aggregates them and forwards them to the EPA.

4.2. Other Sources of HFCs, PFCs and SF_6

107. The USA reported emissions of HFCs, PFCs and SF_6 from various sources including aluminium production (PFCs), semiconductor manufacturing (HFCs, PFCs, SF_6), magnesium production (SF_6) and processing, and electrical equipment (SF_6). Data are mostly provided through industry partners or trade organizations ensuring the confidentiality of producers. The degree of completeness of the reported data varies between sources (100 per cent reported for HCFC-22 producers, 94 per cent for aluminium producers, and around 50 per cent for semiconductor producers) and, where necessary, a scaling up of the data is done by the EPA. Tier 2 or greater methodology is used for emission estimates from production of aluminium and HCFC-22, and combined methodologies are employed for the estimates from the semiconductor industry. Estimates from the magnesium industry are calculated on the basis of U.S. Bureau of Mines data and gas usage information provided by producers to the EPA, and other information from literature sources. Estimates for electrical equipment were based on information from SF_6 producers and assumptions as to the capacity used, gas replacement levels, shares of gas sold to electric power systems and equipment manufactures. Potential emissions were only partly reported in the CRF (e.g. they were missing for consumption of PFCs and SF_6).

4.3. Cement manufacture

108. The emissions increased from 1990 to 1998 by 18 per cent. The emissions estimation methodology is consistent with the IPCC tier 2, as described in the Good Practice Guidance,

based on clinker production, reflecting the recycled cement kiln dust (CKD) inside the clinker kiln, and with particular focus on production of masonry cement. The activity data were obtained from the U.S. Geological Survey (based on questionnaires sent to domestic clinker and cement manufacturing plants). The emission factor is based on an equation reflecting CaO content and CKD. Different reasons for uncertainty are identified in the NIR and mostly quantified, but an uncertainty has not been derived.

4.4. Other industrial sources

109. N_2O emissions from production of adipic acid and nitric acid are estimated using methods recommended by the Good Practice Guidance based on facility specific data for adipic acid and a production weighted generation factor for nitric acid. Activity data are mostly published in industry journals. There are small uncertainties because i) in the case of adipic acid, plant specific activity data were calculated from national production figures using the published capacities, and ii) in the case of nitric acid, the generation factor is based on a 1993 estimate whereby 20 per cent of the US facilities use NSCR techniques. Production data may not reflect the total production due to internal plant use (particularly in the case of production of fertilisers and explosives). The variety of production technologies also contributed to the uncertainties.

110. Published activity data were used to estimate emissions from limestone and dolomite use and soda ash, manufacture and consumption. The emission factors are set by stoichiometry. The methodology used is from the IPCC guidelines. The main source of uncertainty is in estimating the consumption of limestone for the different processes (e.g., different types of glass manufacturing) the availability of information about the variations in the chemical composition of limestone, and the partly unspecified statistical information on the quantity of limestone consumed.

111. Emissions of CO_2 from amonia production are estimated by multiplying annual production data by the default factor given in the IPCC guidelines. The uncertainties could be reduced by applying factors specific to the feedstocks used, in accordance with the methodology in the 1996 revised IPCC guidelines.

112. Lime manufacture emissions were recently estimated by using the 1996 IPCC guidelines methodology (total lime production x EF). The activity data were published by the U.S. Geological Survey. The recovering of CO_2 during sugar refining and the precipitated calcium carbonate (PCCC) production influenced the uncertainty of the results. In order to avoid underestimating the emissions, the Good Practice Guidance recommends the application of a methodology which is based on estimations for the different types of lime.

5. <u>Areas for further improvements</u>

- Reallocate industrial process emissions currently reported under the Energy sector.
- Incorporate the Good Practice Guidance methodology for lime.
- Apply the revised 1996 IPCC guidelines for ammonia production.
- Account for CO_2 reabsorption for lime use (suggestion by National Lime Association).
- Expand partnerships with industry to make more use of plant specific information.
- Check the possible emission sources for N_2O mentioned in the IPCC guidelines.

- Sponsor research (e.g., PFC measurement campaign for aluminum slopes for U.S. smelters).

D. SOLVENT AND OTHER PRODUCT USE

113. The 1996 revised guidelines specifies that the use of N_2O as carrier gas, anaesthetic and propellant should be included under the solvent and other product use category. Only recent figures for NMVOC are reported in the US NIR and CRF.

114. An analysis of all the complete 2000 CRF submissions shows that 10 countries have included emission figures for product use of N_2O. The medium value compared to the total N_2O emission is 2.2 per cent (values differ widely from 1 – 10 per cent). Emissions occur mostly from the use of N_2O for anaesthetic purposes and these emissions should be checked for future inclusion in the United States' inventory.

E. AGRICULTURE SECTOR

1. General overview

115. This sector includes four out of the 17 sources that are considered " key sources" in accordance with the key source assessment carried out by the secretariat. In 1998, this sector was responsible for eight per cent of total United States' greenhouse gas emissions.

116. The EPA estimates this part of the inventory using statistical data gathered and published by the USDA. Other sources of public information are the Department of Commerce (DOC), United Nations Food and Agriculture Organisation (FAO), and professional associations. Relationships between these organizations are voluntary rather than formal.

117. The USDA applies QA/QC to the information it supplies for the inventory, so the EPA does not apply additional QA/QC to this data although it does apply the same QA/QC to the subsequent inventory estimates as for other sectors. This includes documentation of the procedures in place. Procedures will be reviewed as part of the QA/QC plan being developed.

118. Recalculations have not so far been applied to this sector. However, since the submission of the inventory for the years 1990-1998, improvements have been made in activity data, emission factors and methodologies. These improvements will be applied to future updates of the inventory. This will lead to a full recalculation for the time series of at least three out of the four key sources that correspond to agricultural activities.

2. Consistency with the IPCC guidelines and the UNFCCC reporting guidelines

119. For the methane production from enteric fermentation, the methodology depends on emission factors derived using a mechanistic model of the function of the rumen (EPA, 1993), rather than the energy balance approach used in the IPCC 1996 guidelines. The CH_4 and the N_2O emissions estimates from manure use the same population data, which is consistent with the Good Practice Guidance, but the population data used for CH_4 estimates from enteric fermentation differ to some extent, as described briefly below.

3. Key sources

120. The four key sources identified in the assessment were: direct N_2O emissions from agricultural soils, CH_4 from enteric fermentation, indirect N_2O emissions from agricultural soils and CH_4 from manure management.

3.1. Direct N_2O emissions from agricultural soils

Trends

121. Direct emissions of N_2O from soils were 194.51 Tg of CO_2 equivalent (CO_2 equiv.) in 1990 and and 219.10 Tg CO_2 equiv. in 1998, corresponding to a 12.64 per cent increase, mainly due to higher emissions from agricultural soils.

Methodologies

122. Estimation of direct N_2O emissions followed the revised 1996 IPCC methodology and national methodologies, the latter being used to account for non-manure commercial organic fertilisers including compost, dried blood, sewage and tankage (dried animal residue freed of fat and gelatin). The assumptions made and the information sources are clearly described in the NIR.

Activity data

123. Annual synthetic and organic fertiliser consumption data were taken from published statistics for use of commercial fertilisers. Statistics on manure are published as a sub-category of organic fertilisers, but this sub-category was not used for the calculations, which are derived from estimates of the amount of manure used as fertiliser made in the manure management section of the inventory. The published statistics on manure could be used for cross-checking. Fertiliser data are published on a yearly basis from July to June. To map these data onto calendar years, 65 per cent of the given amounts of fertiliser are assigned to the former calendar year. The remaining 35 per cent are assigned to the months from July to December in the current year. For the 1998 inventory, an extrapolation of the fertiliser data was used to complete the July-December segment because data had not yet been published.

124. The amount of sewage sludge applied to soils was obtained from government publications and surveys. All assumptions relating to the amount of crop residues applied to soils and the fraction of nitrogen in manure residues and in sewage sludge are clearly set out and discussed in the NIR.

Emission factors

125. Partitioning ratios between the different pathways for nitrogen applied to soils were taken from the 1996 revised IPCC methodology and from the IPCC Good Practice Guidance. Additional information was taken from peer reviewed research papers and expert opinion.

Additional information provided during the review

126. The USA explained how the methodology for manure management has undergone significant improvement, particularly the nitrogen excretion rate for dairy cattle and swine. As a

result the implied emission factors are now in line with those used in countries with similar herds and consistent with the revised 1996 IPCC guidelines and the Good Practice Guidance.

Uncertainty

127. The NIR provides a qualitative analysis of the uncertainty in the activity data and the emission factors.

3.2. CH_4 enteric fermentation in domestic livestock

Trends

128. The emissions of CH_4 from enteric fermentation were 120 Tg CO_2 equiv in 1990 and 123.68 Tg CO_2 equiv. in 1998. The 3 per cent increase is due to an increase in the beef cattle population. Emissions from dairy cattle remained almost constant in spite of a decline in dairy cattle population, due to an increase in milk production.

Methodologies

129. The methodology used depends on emission factors derived using the mechanistic model of the rumen (EPA, 1993) rather than the energy balance approach outlined in the IPCC 1996 methodology.

Activity data

130. The activity data are taken from USDA statistics and referenced in the NIR. The non-dairy cattle population reported in the CRF differs from that used for manure statistics. Differences were because calves of less than 6 month old are not included for the enteric fermentation calculations but are considered for the waste management section. Another source of differences is the way in which slaughter is accounted for in the yearling and weanling fed-lot systems. These systems differ in the sequence and number of days animals are kept in fed-lot prior to slaughter.

Emission factors

131. Enteric fermentation emission factors were obtained for typical animals by regions using the mechanistic model of the rumen. The country was divided into five regions based on climate and type of feed. Each state was assigned to one region (i.e., north Atlantic). A typical animal, by age segment and function, was assigned to each region (i.e., 12-24 months dairy replacement heifers). To obtain the EF, the model was applied to each typical animal taking into account the type of feed. For dairy cows in each state, the model was applied every year to estimate new EF, taking into account the recorded increase in milk production in the state.

Transparency

132. From the method described above, two choices are available. One is to aggregate the populations of each type of animal by state within the region and then to multiply the corresponding EF. Another is to apply the EF of each typical animal to the corresponding activity data within the state. From these values the national totals can be obtained adding by region or by state. This choice has lead to *not applicable* (NA) entries in the CRF. However, given that each one of these regions corresponds to only one climate region, both choices could have enabled completion of table 4.B(a) without using NA, and this would have increased transparency. With

the information provided in the NIR and the CRF, it is not possible to trace the emission factors to the gross data on animal mass, feed, milk production and use.

Results from previous review stages and responses to S&A

133. An improved characterization of cattle population is being used, and as a result, the implied emission factor (IEF) found in the CRF is now in line with those used in countries with similar herds and consistent with the revised 1996 IPCC guidelines and the Good Practice Guidance.

3.3. Indirect N_2O from nitrogen used in agriculture

Trends

134. Indirect emissions of N_2O from agricultural soils showed a small increase of 8 per cent in the period. They changed from 82.21 Tg CO_2 equiv. to 88.81 Tg CO_2 equiv. between 1990 and 1998. Most of the difference is due to revised estimates of surface run-off and leaching.

Methodologies

135. To estimate indirect N_2O emissions the USA used the methodology in the revised 1996 guidelines, supplemented by country specific methodologies as described in section 3.1 above.

Activity data

136. Annual synthetic and organic fertiliser consumption data are also used for the calculations in this sector. They are described in section 3.1 above.

Emission factors

Partitioning ratios between the different pathways for nitrogen applied to soils and then available for secondary emissions were taken from the 1996 revised IPCC methodology and from the IPCC Good Practice Guidance, with some modifications as explained in the NIR.

Additional information provided during the review

137. The USA explained that the methodology for manure management has undergone significant improvement, particularly the nitrogen excretion rate for dairy cattle and swine. As a result, the IEF is now in line with those used in countries with similar herds and consistent with the revised 1996 IPCC guidelines and the Good Practice Guidance.

3.4. CH_4 from manure management

Trends

138. CH_4 emissions from manure management systems were 55.05 Tg CO_2 equiv. in 1990 and 84.04 Tg CO_2 equiv. in 1998. This is an increase of 52.7 per cent, due to a shift in the dairy and swine industries towards larger facilities more likely to use liquid systems for manure management.

Methodologies

139. The revised 1996 IPCC methodology for the estimation of methane emissions from manure management is largely based on the methodology used by the USA (EPA, 1992, 1993). The latter reference, although a milestone in the field, relies heavily on expert judgement. The USA explained that an updated study is being used for new inventory submissions. The CH_4 and the N_2O emissions estimates derived from manure use the same population data, which is consistent with the Good Practice Guidance.

Activity data

140. The activity data related to livestock population were taken from USDA statistics as referenced in the NIR, with some inconsistencies for the non dairy cattle population for enteric fermentation emissions as explained above in section C.2. Data on farm size distribution for dairy cows and swine were taken from statistics from the DOC. Use of manure management systems was taken from an EPA study (1992)..

Emission factors

141. The EF used are based on local methodologies (EPA, 1993, 1992) which were the basis for the IPCC methodology but need updating

Results from previous review stages and responses to S&A

142. The livestock characterization led to the seemingly high IEF found in the CRF. A better characterization of typical animal mass and waste characteristics of beef and dairy cattle, swine and poultry brought the IEF into line with those used in countries with similar types of livestock and with the Revised 1996 IPCC methodology and the Good Practice Guidance.

4. Areas for further improvements

4.1. Planned and/or on-going work by Party

143. The USA has an ongoing effort to improve the inventory. Changes on activity data and methodologies were explained. Some improvements have been put into practice but will not be reflected until the next submission of the inventory.

144. The ERT was provided with a copy of the sector draft for the 2001 submission where detailed explanation is provided for the changes already implemented. For enteric fermentation, better population characterization based on production practices for cattle had enabled state-specific emission factors for the corresponding livestock segment to be obtained. On the methodology side, an energy-balance tier 2 model approach based on the Good Practice Guidance (IPCC, 2000) is being put into use together with improved model input data. For manure management systems, better population characterization based on production practices for cattle and swine had enabled state-specific emission factors for the corresponding livestock segment to be obtained. Other improvements concern volatile solids (Vs) and methane conversion factors (MCF). Increases in N_2O are due to the combined effect of increases on the dairy estimates and drops in the swine and beef estimates, as well as the more detailed data used.

4.2. Issues identified by the ERT

145. No information is given in the NIR or the CRF as to whether the population estimates are one-year data or three-year estimates. The USA said that data in the CRF and the NIR are annual.

146. Livestock population could be allocated by climate in table 4.B(a). Also, there is some inconsistency between total non-dairy cattle in Tables 4.A and 4.B(a), as well as between dairy cattle in Tables 4.B(a) and 4.B(b). These two issues have been addressed in section 3.2 above.

147. For enteric fermentation and manure management, the USA uses a very disaggregated model which makes it difficult to fill in the CRF, hence also making QC difficult. Small rounding errors can be found in the emission estimates. These issues are typical of the way values are stored and displayed on commercial spreadsheets. As a consequence, there are some minor inconsistencies in the CRF tables within the sector. Sometimes links to other data files are retained, in other cases values are fed in by hand or by the “copy/values” function, which makes review more difficult.

148. Table 4.F of the CRF lacks a column for the burning efficiency parameter used in the 1996 IPCC methodology. In addition, the USA included a new factor, “combustion efficiency”. This factor is explained in the NIR (footnote 16 in the Agriculture chapter). To improve transparency, the suggestion was made to the USA to feed into the corresponding column “fraction burned on the field” the product “fraction burned on the field*burning efficiency*combustion efficiency”. Although the change has been documented in the NIR it could also be recorded in the documentation box below Table 4.F.

149. There are many references to private communications and expert opinions within the agriculture sector, particularly with respect to nitrogen in manure or sewage sludge, or in residues burning. This may indicate the need for additional efforts to compile technical reports that are not commonly indexed. It also may be a measure of the need for further studies in these areas. The record keeping of this kind of documentation is also the weakest in the information system of the inventory office. Given the informal and “soft” nature of these references, extra care needs to be taken with the archiving and recording of this kind of information.

150. The review team was given access to Excel notebooks containing the models and data used for the inventory. The content is consistent with the methods and assumptions in the NIR. However, a better documentation of the used formulae and the inclusion of blocks and links would facilitate transparency, QC checks and record keeping of how the methodology evolves over time.

F. LAND-USE CHANGE AND FORESTRY

1. General overview

1.1. Introduction

151. Changes in C stocks from forests and soils and landfilled non-forest stocks represented a net sequestration of 1160,000 Gg CO_2 in 1990 (about 19 per cent of total Unites States’ gross emissions) and a net sequestration of 773,000 Gg CO_2 in 1998 (representing about 11 per cent of total emissions). As required by the IPCC guidelines, LUCF net removals are not included in the national GHG totals.

1.2. Institutional arrangements

152. The U.S. Department of Agriculture (including the Forest Service) develops the estimates of changes in carbon stocks and input to the NIR, with close collaboration with the Colorado State University, Fort Collins, CO, for the agricultural soil carbon stocks. The EPA, through the consulting firm ICF, develops the estimates for the carbon fluxes associated with landfilled yard trimmings. The EPA has started to fund some USDA Forest Service work to ensure that the necessary data will be provided.

1.3. Completeness

153. The information provided is generally complete although the inventory under review has an incomplete time series of non-forest soil carbon stocks (only 1990 to 1992). Reasons are provided in the NIR and discussed below. Furthermore, the inventory provides no data for IPCC sub-categories 5B and 5C (land conversion and abandonment of managed lands). Finally, a complete time series for emissions from liming and dolomite applications is reported in the NIR but does not appear in the CRF tables because the other non-forest soil categories series were not complete.

154. The US LUCF inventory does not cover emissions from hydroelectric reservoirs, fluxes from urban forests and trace gases emissions from prescribed fires or other potential forest fires of human origin.

1.4. Transparency

155. The review team noted the need to improve transparency in the NIR by providing a more detailed explanation of methodologies, and in particular, models used for both the forest estimates and the soils. It suggested that an annex be added to the report. References and background documentation were provided to the team during the review.

2. Consistency with the IPCC guidelines and the UNFCCC reporting guidelines

156. Methods in the revised 1996 IPCC guidelines were followed to estimate all three components of changes in non-forest soil carbon stocks (liming, management of organic and mineral soils), with a more complex method used for estimating the forest stocks.

157. The USA used the CRF tables in a way that suited their national circumstances partly because of the reporting format's deficiencies, but mostly because the categorization and methodologies for United States' forest stocks are not compatible with the IPCC structure. Where possible, the reporting in next year's inventory will be more consistent with the CRF.

2.1. Changes in forest carbon stocks

Trends

158. The apparent forest flux decreased from 1,005,400 Gg CO_2 /yr. from1990 to 1992 inclusive, to 627,900 Gg CO_2/yr. over 1993 to 1998. The apparent harvested wood flux (including landfilled wood products (WP)) is reported stable from 1990 to 1998 at 136,800 Gg CO_2.

Methodologies

159. Forest stocks are comprised of 6 pools: trees, forest floors, forest soils, understory vegetation, harvested wood products in use and wood products in landfills. Annual net C sequestration in forest is estimated on average over 10 year periods. For 1993 to 1998 the estimates were based on projected changes in forest stocks for 2000. A series of models are used including one for the harvested wood products. More information was provided on these models on request, including a copy of Birdsey et al. (2001), which could serve as a basis for additional information that could be inserted in an annex to the NIR.

160. The fundamental approach for the forest sector is a stock change approach, based on surveys completed every five years which subdivide United States' forests into characteristic ecosystems and use many flux data, such as decay rates, to estimate average changes in stocks, including changes in the soil and litter pools, over the five year period.

161. The soil pool, that represents about 50 per cent of the total forest flux, was included for the first time in 1996. Uncertainty was stated as the reason for not including it earlier. Woody debris in the forest floor and soil are not inventoried (they will be in about 10 years). Estimates of C stocks for those pools are based on rather inconsistent literature data contributes to increasing the uncertainty. For harvested wood products, the production method was used, which covers only the domestic harvest, regardless of whether it is in part exported, and takes no account of imports. The ERT felt that the production approach does not provide for an accurate estimate of domestic stocks.

162. The harvested wood flux estimates (in use and landfills) are identical throughout the period 1990 to 1998. They represent a 10-year average between two estimates of stocks (1990 stocks and projections for 2000) provided by the HARVCARB model. Given the availability of annual data on harvesting and WP production it would be desirable to report annual stocks data.

Coverage

163. Fluxes arising from land use change activities (deforestation, afforestation, abandoned managed lands reverting to forest) are not reported under IPCC categories 5B and 5C and are assumed to be encompassed in the overall estimate of fluxes in forests. This reduces transparency. The ERT noted that a detailed breakdown of deforestation and afforestation could be carried out (as provided by the USA in FCCC/SBSTA/2000/MISC.6/Add.1), but updating these estimates is not part of the current inventory development plan. Explanations of the variations in the area of the forest land and/or in the CO_2 sinks could be made clearer in the NIR.

164. The 1998 inventory covers timberlands, *other forests* (which are less intensively managed and for which less data are available) and reserved forests. The forest C stock estimates exclude Alaska and Hawai where it is assumed that the changes in stocks are zero. Experts indicated they do not know how valid this assumption is, especially for Alaska, and said that this increases uncertainty. There are plans to inventory some parts of Alaska (but not the interior).

Verification and uncertainty

Various cross checks have been made:

- Using the flux method (using growth, removals and mortality data from the inventory). reference (Birdsey 1992);
- Measurements of CO_2 atmospheric concentrations reported in Fan et al. (1998) show that fluxes from the United States forest are consistent with those derived from fluxes. Additional CO_2 concentration data by Pacala et al., is to be published in Science in June 2001;
- CO_2 measurements from flux towers, although not a random sample, compare well with estimates made under similar forest conditions.

165. The C stocks on private timberlands are estimated to be 22Pg G +/- 3 Pg at a 95 per cent confidence interval (rigorous error analysis) which represents about 14 per cent uncertainty. This is not necessarily applicable to the "other forests" category nor to public timberlands. Based on expert judgement, the uncertainty of C flux estimates for the total forest was estimated to be 15 per cent. Estimates for soil C, based on a model and data from forest ecosystem studies, largely determines the uncertainty. The relative uncertainty of estimates for the various carbon pools, considering their contribution to the total flux estimates, is (ranked by decreasing uncertainty): soil, harvested products, coarse woody debris, litter and biomass.

166. Estimates of CO_2 uptake for the "other forests" category are more uncertain than for timberlands because sufficient field plot data is lacking on these forest lands. However, independent estimates of harvested wood volumes are obtained from mill surveys and other sources, so that estimates of wood removals from non-timberland areas are quite accurate.

Additional information provided during the review

167. Forest fires are considered to be natural, even if they occur on the forest lands covered by this inventory and, therefore, trace gases are not reported. The C emissions are considered as being captured by the forest inventory and C stocks estimates. Fires statistics exist and are available upon request. Trace gases emissions from prescribed fires are not reported. Areas burned are reasonably well known but other data (type of biomass burnt, moisture content, etc.) are likely to be very uncertain.

168. C stocks for the next inventory are being updated with the 1997 forest survey data. New methods and models are being developed for all pools and should be applied post 2001. The USA said that this will increase the confidence in the range of C stocks estimates. Recalculations backwards to 1990 will be performed. The US Forest Service indicated that preliminary results show CO_2 sequestration estimates in soils will be reduced. They are likely to show that the sequestration in soils is better explained by the LUC legacy than by the impact of harvesting activities.

3. Areas for further improvements

169. The transparency would benefit from the inclusion of a LUCF annex in the NIR including, among other things, the underlying assumptions of the various models used, and an explanation of

the changes in forest areas. The USA plans to develop estimates of annual (real) changes in carbon stocks following the introduction of a new forest inventory whereby one fifth of all plots will be collected every year. The forest inventory upgrades are being made for reasons other than carbon accounting. The ERT noted plans to make measurements of soils carbon, for which stock changes are currently derived mainly from the literature. Separate compilation of stock changes on forest and agricultural land has at least the potential for inconsistencies at the boundary, so future work should be coordinated between the two parts of the inventory.

4. Changes in non-forest soil carbon stocks

Trends

170. The NIR reports that mineral soils removed 66,600 Gg CO_2/yr. between 1990 and 1992 inclusive and that organic soils lost 27,100 Gg CO_2/yr. over the same three-year period. Emissions from liming of soils increased by 36 per cent, from 8,088 Gg CO_2/yr. in 1990 to 10,943 Gg CO_2/yr. in 1998.

Methodologies

171. The USA has estimated emissions and removals of soil carbon by using the IPCC default method. This is described in Eve et al. (2001). Climate categories, soil types and tillage systems are identical with the IPCC default definitions. Land use classifications differ a little, but the USA has established the relationship between the United States' system and the IPCC defaults by using the appendix to Chapter 5 of the Workbook. Emissions and uptake values differ somewhat between Eve et al. (2001) and the NIR; this is due to revised area data, particularly for hay and pasture.

Activity data

172. The method uses agricultural lands and cropland and grazing land areas by soil type and management regime derived from the USDA National Resources Inventory (NRI) for 1982 and 1992. The 1992 NRI was the most recent available at the time of developing the inventory, and because projections had not been used owing to uncertainties, the USA had not calculated soil carbon emissions and removals for 1993 and subsequent years. Since the time series was partial the data were not included in the sectoral totals for any year in the inventory under review. The 1997 NRI has now been published and, along with projections for 2000, has been used to produce a complete time series in the updated inventory. Areas for low tillage come from the Conservation Tillage Technology Information Center (CTIC).

Emission factors

173. IPCC base and tillage factors and organic soil loss rates were used, on the assumption that half the IPCC 20-year mineral soil carbon losses would occur over this ten year accounting period.

Additional information provided during the review

174. The National Resource Inventory provides the land use change matrix required for the mineral soil calculation. In future the NRI will be completely updated every five years with one fifth of the sampling points updated annually. This will be used to estimate the fraction of

rotational land uses. In the current estimates, the CTIC areas were scaled back by between 60 per cent and 70 per cent to represent the fraction of land under long-term low tillage. Forest soils are accounted separately and there is inevitably some overlap, but this probably accounts for less than 3.7 Tg CO_2/year. The overall uncertainty in the current estimate was put tentatively at 20 to 25 per cent. The revised 1990 estimates in the next update of the inventory are about 30 per cent lower than those in the inventory under review, mainly because of decreased area coverage and more accurate treatment of averaging.

Areas for further improvements

Planned and/or on-going work by Party

175. The USA is considering future developments of the methodology, possibly a revised IPCC method with longer transition times and associated uncertainty analysis. Work is ongoing using the Century model and will be published in 2001.

Issues identified by the ERT:

176. The ERT asked specifically about the applicability of IPCC default assumptions, particularly transition times, to United States' conditions. This is of course an issue for many developed countries because the IPCC methods are more suited to tropical conditions. It will be dealt with by methodological development in the context of the likely work by the IPCC itself. The new work also covers other generic issues, such as the need for consistency between input databases, particularly the forest/agriculture interface. The ERT felt that greater transparency in the existing CRF tables could have been achieved by using categories 5B and 5C. Finally the ERT asked about the availability of measured data for model calibration and verification. Currently this is achieved by universities and other research institutions, which are responsible for work at about fifty sites across the USA. A national system with more intensive monitoring is under consideration.

5. Changes in non-forest carbon stocks in landfills

177. This category, reported for the first time in the 1998 inventory (in "Other" in the CRF), accounts for carbon storage in landfilled yard trimming (grass, leaves and branches). The decrease in the yard trimmings landfill disposal rate has resulted in a decrease in the rate of landfill carbon storage from 17,800 to 8,300 Gg CO_2 between 1990 and 1998.

178. The rationale for including this storage was provided by EPA representatives. Empirical data indicates that landfilled yard trimmings do not decompose completely. It seemed logical to account for that C storage term in the LUCF chapter which is aimed at tracking land use emissions and removals due to anthropogenic activities. Yard trimming data are based on extrapolation of waste composition surveys, which means that activity data are uncertain. A storage factor of 0.19 Gg C/wet Gg of yard trimming is multiplied by the mass of yard trimming. This factor, while based on a single study (Barlaz, 1997) is thought to be conservative. Methane emissions from all waste, including trimmings, are included in the waste sector. It has been verified that the yard trimmings C storage factor and the decay rates included in the Waste Sector methodology are within 10 to 15 per cent of each other.

179. Areas for further improvements include the need for better data on the quantity of yard trimmings disposed of, and a better understanding of the fate of lignin in landfills.

G. WASTE SECTOR

1. General overview

180. This sector comprises four sources of GHG emissions, namely landfills, waste combustion, wastewater treatment and human sewage. Overall waste activities generated emissions are relatively small, constituting about 3.6 per cent of total US GHG emissions in 1998. However, the sector includes one of the17 key sources based on the IPCC good practice level assessment, namely GHG emissions from landfills. Landfills are the single largest anthropogenic source of methane in the USA.

181. The EPA has the responsibility for calculating emissions from this sector. However, it relies on a number of different offices in the EPA e.g., the Office of Atmospheric Programs, the Office of Solid Waste and the Office of Air Quality Planning and Standards, for its data sources. In addition, data and other information are also obtained from the Bureau of Census in the Department of Commerce, the FAO, the trade association - *Biocycle* journal, the Solid Waste Association of North America (SWANA), equipment vendors, state governments and the IPCC.

182. Overall, the information provided in the NIR is consistent with the IPCC and UNFCCC reporting guidelines. It is also complete.

183. There are a lot of variables driving activity data and emission factors in this sector. Assumptions made in the calculations are well documented in the NIR .

2. Key sources

184. Based on the IPCC good practice level assessment there is only one key source in this sector, namely, methane emissions from solid waste disposal sites. This source constitutes approximately a third of all methane emissions from 1990 to1998. Between those years, methane emissions from this source remained relatively constant at about 220,000 Gg CO_2 equiv. The reason for this is that although municipal solid waste (MSW) generation and corresponding methane emissions increased during this period, the amount of landfill gas collected and combusted also increased. These two offsetting trends kept the methane emissions nearly constant.

185. The methodology employed for estimating emissions of methane is a country specific model based approach consistent with IPCC Good Practice Guidance. Essentially, a model estimates emissions based on the analysis of population of MSW landfills; landfill specification data are then extracted and used in calculating gross potential emissions. Estimates of methane that is recovered and either flared or used for energy purposes and the amount oxidized in landfills are subtracted from the gross methane emissions.

186. The United States' inventory team preferred this method because of the many uncertainties in the variables for estimation in the higher tier given the limited data set. For instance, the use of the IPCC tier 2 first-order decay model requires data on the methane generation potential and rate constant on a landfill by landfill basis. Such data are not available and are quite uncertain. Methane measurement data are available for 85 landfills out of over 2300 presently operating in the country, and the USA believes they are preferrable to the IPCC defaults. Moreover, the EIA which also has responsibility for calculating estimates for congressional requirements employs the tier 2 methodology. They assume the nation has one type

of landfill and assign some average coefficients for the methane generation rate and potential which are based on actual measurement data. The review team was informed that the results from the two approaches were close, which provides a cross-check.

187. A major data source is *Biocyle,* a trade association journal which provides annual waste disposal data from 1990 to 1998. The distribution of waste-in-place was based on the 1987 EPA survey on solid waste, while methane generation factors come from EPA surveys. Information on the methane flares from landfills were obtained from vendors of flare equipment, and methane recovery data for energy purposes were obtained from the EPA voluntary program Landfill Methane Outreach Program (LMOP).

188. In addition to the above, emissions of methane from industrial landfills were simply assumed to be 7 per cent of total methane emissions from municipal landfills.

189. Major sources of uncertainties associated with the inventory estimates of methane from landfills include limited recent data on landfill coefficients due to different management practices; lack of information on area landfilled and total waste-in-place; variability in oxidation between landfills; and the limited coverage of the flaring data. Using a Monte Carlo analysis, the overall uncertainty in the methane emissions from this source is put at +/- 30 per cent.

190. The EPA does not plan any new survey to collect better data from this source owing to cost and resource limitation. However, the agency plans to continue to work with the industry associations like SWANA, which is undertaking surveys of flares. This should decrease the overall magnitude of the uncertainties in the estimate

3. Non-key sources

3.1. Wastewater treatment

191. Emissions from wastewater are very small (about 3,400 Gg CO_2 equiv. in 1998) relative to those from landfills and the overall GHG emissions in the USA. They have increased slightly from 1990 to 1998, reflecting population increases. Wastewater methane emissions were calculated using default IPCC methodology. Emissions are related to population and emission factors. The population data were taken from the US Census Bureau, while the emission factor was obtained from a peer reviewed study conducted in 1972 and assumed constant from 1990 to 1998. In subsequent inventory calculations the United States' inventory team plans to use a more current estimate of this emission factor.

192. Due to data problems, methane emissions from industrial water sources were not estimated. The NIR, however, stated that based on expert judgement, these emissions may be significantly more than methane emissions from domestic wastewater treatment. The team was also informed of ongoing work to estimate emissions from the largest industrial sources.

3.2. Human sewage

193. Nitrous oxide emissions from human sewage were estimated using the IPCC methodology with a slight modification. The modification involves the exclusion of nitrous oxide emissions associated with sewage applied to soils, which are included in the emissions from agricultural soils.

194. Emissions from this source are very small and have increased slightly between 1990 and 1998, reflecting the growth in the United States' population and per capita protein intake.

3.3. Waste combustion

195. The scope of emissions from this source includes CO_2 emissions from combustion of (fossil derived) plastics and N_2O from combustion of all waste. For the first category the USA team agreed that these emissions might well be included in the energy sector to the extent that the emissions are associated with waste-to-energy activities.

196. The mass balance approach was used in calculating CO_2 emissions from plastic combustion. Although, the emissions are very low, the trend shows approximately a 25 per cent increase between 1990 and 1998. This reflects the increase in per capita plastic use in the United States economy in recent times.

197. The IPCC default approach was used for the N_2O emissions. The emission factor used lies within the range given in the IPCC default value. Overall emissions from this source are very small. There are, however, on-going improvements planned which might lead to better estimates and an increase in emissions, but they are unlikely to significantly change the overall total GHG emissions in the USA. These improvements will include emissions from new waste types such as textiles, scrap tyres and rubber in MSW and hazardous waste in the incineration analysis, and the updating of carbon contents for unspecified plastic resins.

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