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REPORT OF THE INDIVIDUAL REVIEW OF THE GREENHOUSE GAS INVENTORY OF SWEDEN SUBMITTED IN THE YEAR 2001[1]

(In-country review)

I. OVERVIEW

A. Introduction

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

2. Sweden has volunteered for an in-country review, which took place from 19 to 23 November 2001 in Stockholm at the headquarters of the Swedish Environmental Protection Agency (EPA). The individual review was carried out by a team of nominated experts from the roster of experts, and was coordinated by the secretariat. Members of the expert review team (ERT) participating in the review included Mr. Jan Pretel (Czech Republic) with responsibility for general issues, Mr. Francis D.Yamba (Zambia) with responsibility for the energy sector, Mr. Eilev Gjerald (Norway) with responsibility for industrial processes, Mr. Samuel A. Adejuwon (Nigeria) with responsibility for agriculture, Ms. Dominique Blain (Canada) with responsibility for land-use change and forestry (LUCF), Mr. Eduardo Calvo (Peru) with responsibility for waste, Ms. Olga Pilifosova (UNFCCC secretariat) and Mr. Stelios Pesmajoglu (UNFCCC secretariat). Ms. Dominique Blain and Mr. Eduardo Calvo were appointed to be lead-authors of this report**.**

3. At the beginning of the review, the host country officials and experts provided a general overview of inventory preparation, followed by sectoral presentations. Thereafter, sectoral sessions were conducted in parallel. During those sessions, national experts responsible for the respective sectors clarified key issues related to inventory preparation after which there was a question and answer session. Where answers could not be provided immediately they were submitted to the team in the course of the week.

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[1] In the symbol for this document, 2001 refers to the year in which the inventory was submitted and not to the year of publication. The number (2) indicates that for Sweden this is an in-country review report.

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

4. The main findings of the in-country review were presented to the host country team on 23 November 2001. A draft written report was submitted to Sweden on 18 March 2002 and its comments thereon have been carefully considered by the ERT and incorporated into the final document.

B. Inventory submission and other sources of information

5. Sweden submitted on 11 April 2001 to the COP through the secretariat, a national inventory report (NIR) in hard copy and electronic form. It contains information on inventories for all years from the base year (1990) to the most recent year (1999), in accordance with the provisions given by decision 3/CP.5.

6. The inventory estimated anthropogenic emissions of all accounted GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6), as well as precursor gases (NO_X, CO, NMVOC, SO_2). It was submitted in the common reporting format (CRF) using the CRF software application.

7. Prior to the country review, the secretariat had provided the ERT with the following documents: a synthesis and assessment (S&A) report of the 2000 and 2001submissions; Sweden's responses to these; a status report of the 2001 submission; guidelines for the preparation of the review report and a list of *key sources* as defined by the secretariat in terms of their absolute and trend levels of emissions in accordance with the tier 1 assessment as described in the *Intergovernmental Panel on Climate Change (IPCC) Good Practice and Uncertainty Management in National GHG Inventories*, hereinafter referred to as IPCC good practice guidance.[3] For all sectors the preliminary findings identified in the S&A report of GHG inventories submitted in 2001 were addressed during the respective sessions. Answers to these findings were discussed during the respective sectoral sessions.

8. Host country experts provided additional sources of information, such as annual reports, research reports and supporting information, during the in-country visit. These were not part of the inventory submission, but in most cases are quoted in the NIR.

C. Emission profile, trends and key sources

9. Tables 1 and 2 below provide data on emissions by gas and by sector from 1990 to 1999. The most important GHG in Sweden's inventory is CO_2, which in 1999 accounted for 80% of total emissions, followed by methane (9%) and N_2O, (10%).[4] The energy sector accounted for 77% of the total emissions, followed by the agriculture sector (11%), industrial processes (9%) and waste (3%).

10. Emissions of CO_2 (excluding CO_2 from LUCF) grew by 2.5% between 1990 and 1999, driven mainly by increased emissions from transport (CRF table 10). Methane emissions decreased by 9.5% during the same period mainly due to a reduction in emissions from waste and transport; N_2O emissions increased by 1.5% over the same period due to slight increase in emissions from fuel combustion and industrial processes, compensated by a reduction in N_2O

[3] According to the conclusions of the Subsidiary Body for Scientific and Technological Advice (SBSTA) at its twelfth session, the IPCC good practice guidance should be applied, as far as possible, by Annex I Parties in inventories due in 2001 and 2002 and should be used for inventories due in 2003 and beyond.

[4] In this report the term total emissions refers to the aggregate national emissions based on the CO2 equivalents excluding CO2 in LUCF sector, unless specified otherwise.

emissions from agriculture. Emissions from two industrial gas groups, HFCs and $SF_{6,}$ have grown substantially, particularly HFCs (from 1 Gg in 1990 to 94 Gg in 1995, and 375 Gg in 1999), while PFCs dropped by 25%.

Table 1. GHG emissions by gas, 1990–1999 (Gg)

GHGs	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
Net CO_2 emissions/removals	34,781.60	27,152.98	31,505.57	25,546.71	32,927.47	37,228.65	40,731.88	29,799.89	33,811.20	32,152.87
CO_2 emissions (without LUCF)	55,073.56	56,480.63	54,858.65	54,878.81	59,232.82	58,521.35	63,000.93	57,087.50	58,142.10	56,458.18
CH_4	6,810.30	6,745.06	6,877.99	6,828.89	6,724.15	6,644.30	6,632.51	6,526.75	6,375.45	6,172.59
N_2O	7,156.10	6,941.23	6,785.08	6,952.75	7,117.73	6,892.35	7,103.05	7,074.53	7,334.99	7,260.39
HFCs	1.12	2.91	4.49	17.06	46.86	93.83	140.72	239.22	303.19	375.34
PFCs	440.05	427.31	413.77	402.13	389.74	389.37	343.34	315.91	305.68	329.16
SF_6	81.26	82.22	81.74	88.43	96.80	114.72	103.01	146.03	92.25	96.32
Total (with net CO_2 emissions /removals)	49,270.42	41,351.71	45,668.62	39,835.96	47,302.74	51,363.21	55,054.50	44,102.32	48,222.77	46,386.67
Total (without CO_2 from LUCF)	69,562.38	70,679.36	69,021.70	69,168.06	73,608.09	72,655.91	77,323.55	71,389.93	72,553.67	70,691.98

Table 2. GHG emissions by sector, 1990–1999 (Gg)

GHG SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1. Energy	54,098.26	54,997.86	53,120.43	53,041.76	57,409.31	56,307.83	60,909.65	54,958.39	56,358.64	54,727.25
2. Industrial processes	4,807.55	5,258.85	5,436.27	5,581.09	5,684.17	6,050.41	6,114.13	6,042.86	5,948.99	6,106.65
3. Solvent and other product use	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79
4. Agriculture	7,991.93	7,713.39	7,747.68	7,919.19	7,998.28	7,787.80	7,820.28	7,942.51	7,851.44	7,599.86
5. LUCF	-20,291.96	-29,327.65	-23,353.08	-29,332.10	-26,305.35	-21,292.70	-22,269.05	-27,287.61	-24,330.90	-24,305.31
6. Waste	2,553.86	2,598.47	2,606.53	2,515.24	2,405.54	2,399.09	2,368.69	2,335.38	2,283.81	2,147.43
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

11. Table 3 shows key sources for Sweden for 1999, as identified by the secretariat. These key sources were estimated using the recommendation elaborated in Chapter 7 of the IPCC good practice guidance. More detailed analysis of the key sources is provided in the sectoral chapters below.

12. Sweden has also performed its own key source analysis using level and trend assessments for all years reported. However, this analysis was performed only for activities relating to CO_2 emissions from the energy sector and emissions of other gases in other sectors or subcategories are not taken into account. Therefore, it is not possible to make a comparison with the key source analysis performed by the secretariat. The EPA plans to improve the list of sources in 2002 on the basis of IPCC good practice guidance, new data and the list of key sources identified by the secretariat.

Table 3. Key source assessment for Sweden, for the year 1999 (UNFCCC secretariat)

Key source	Gas	Level assessment %	Cumulative total %	Trend assessment %
Stationary combustion-oil	CO_2	31.5	32	1.8
Mobile combustion-road vehicles	CO_2	25.6	57	12.7
Stationary combustion-coal	CO_2	9.7	67	18.8
Enteric fermentation in domestic livestock	CH_4	4.4	71	2.5
Direct emissions from agricultural soils	N_2O	3.2	74	4.5
Solid waste disposal sites	CH_4	3.0	77	6.1
Iron and steel industry	CO_2	2.9	80	12.2
Stationary combustion-gas	CO_2	2.4	83	6.0
Cement production	CO_2	1.7	84	2.1
Stationary combustion – other fuels	CO_2	1.5	86	1.9
Stationary combustion-oil	N_2O	1.2	87	2.3
Mobile combustion-aircraft	CO_2	1.1	88	
Other (agricultural soils)	N_2O	1.1	89	
Nitric acid production	N_2O	1.1	90	1.0
Mobile combustion-waterborne navigation	N_2O	0.9	91	
Manure management	N_2O	0.9	92	1.9
Mobile combustion-road vehicles	N_2O	0.7	93	2.4
Animal production	N_2O	0.7	93	1.7
ODS substitutes	HFCs[5] and PFCs[6]	0.5	94	5.1
Stationary combustion-coal	N_2O	0.5	94	1.3
Ferroalloys production	CO_2	0.5	95	1.9

D. General assessment of the inventory

1. Completeness

13. Sweden submitted the NIR and the complete set of CRF tables for all years from 1990 to 1999. The inventory covers emissions by sources and removal by sinks for CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 NO_X, CO, NMVOC and SO_2, and summary level estimates for indirect GHG's. The CRF data are consistent with data provided in the NIR. The ERT identified no major omissions in the submitted inventory. Some omissions have been recognized in a number of sectors as indicated below.

14. Mainly due to current limited data availability, emissions from the following source/sink categories were not reported in the 2001 submission: CO_2 emissions from industrial processes (chemical industry) and LUCF (forest and grassland conversion, abandonment of managed land, and partially emissions and removals from soils); methane emissions from the energy sector (railways, oil and natural gas and international bunkers – marine), industrial processes (mineral products and metal production), LUCF (forest and grassland conversion) and from wastewater handling in the waste sector; N_2O emissions from the energy sector (civil aviation, railways, oil

[5] HFCs include HFC23, HFC32, HFC41, HFC4310mee, HFC125, HFC134, HFC134a, HFC152a, HFC143, HFC143a, HFC227ea, HFC236fa and HFC245ca.

[6] PFCs include CF_4, C_2F_6, C_3F_8, C_4F_{10}, CC_4F_8, C_5F_{12} and C_6F_{14}.

and natural gas and international bunkers – aviation), industrial processes (metal production), solvent and other product use (total solvent and other product use) and waste sector (waste water handling).

2. Transparency

15. The NIR and CRF in the main contain the information required by the UNFCCC reporting guidelines and the IPCC Guidelines. In the CRF, emission factors and activity data have been provided for each source where relevant data are available. For the majority of source categories the sources of information related to emission factors and activity data have been provided. Calculation sheets for activity data and emission factors have been provided in a disaggregated manner. The use of indicators (e.g., not occurring (NO), not estimated (NE) and included elsewhere (IE)) was limited throughout the CRF and the ERT noted that they had been wrongly applied in several tables.

16. The ERT noted that the description of changes in methodologies, activity data and emission factors were provided to some extent in the NIR. However, in several instances the information provided on methodologies and activity data was insufficient and not completely transparent.

17. During the visit additional information, including assumptions and research findings, together with the rationales for their incorporation in the estimation procedures, and reference lists, were made available to the ERT. In order to improve the general transparency of Sweden's GHG inventory, the ERT recommended that national inventory experts should augment the reference lists in the NIR, provide more precise descriptions of methodologies and discuss potential changes in sectoral and/or category trends. Sweden acknowledged the need to provide summaries of these methods and a description of differences between them and the IPCC methodologies in the NIR.

18. Sweden mentioned during the visit that no provisions relating to the confidentiality of business or military information had been used in the 2001 inventory submission, which was not specifically mentioned in the NIR.

3. Conformity with the UNFCCC reporting guidelines and the IPCC Guidelines

19. The NIR and CRF are broadly consistent with IPCC and UNFCCC guidelines for estimating and reporting emissions. Both IPCC and country-specific methodologies were used to estimate emissions. In particular, good practice guidance has been applied in the case of the energy, industrial processes and waste sectors. Deficiencies were found in the reporting of non-CO_2 emissions in the transport category and solvent and other product use sector.

E. Cross-cutting issues

1. Institutional arrangements

20. The ERT was informed that Sweden used a multi-agency approach to compile the inventory. The Swedish Ministry of the Environment submits the inventory to the UNFCCC, while the Environmental Protection agency (EPA) is responsible for coordinating preparation and compilation of the inventory. In addition, the EPA makes estimates of non-CO_2 emissions in the transport category and solvent and other product use sector. Statistics Sweden's Environment

Statistics Division prepares, on a contractual basis, the inventories for the following sectors and subsectors: energy, industrial processes (CO_2), agriculture, emissions due to the liming of agricultural soils (in LUCF) and waste. The Swedish Environmental Research Institute (IVL) is responsible for inventorying non-CO_2 emissions from industrial processes and the National Board of Forestry makes estimates of emissions and sinks in the remainder of the LUCF sector.

21. Representatives of the Swedish EPA informed the ERT about forthcoming changes in institutional arrangements aimed at improving the quality and transparency of future inventories. A new entity, the Swedish Methdology for Environmental Data (SMED), has been established on the basis of a formal agreement between the EPA and the Swedish Meteorological and Hydrological Institute (SMHI). SMED will operate as a consortium composed of the SMHI (responsibility for database construction and geographical distribution), the IVL (responsibility for some data collection, emission factors and methodology) and Statistics Sweden (responsibility for statistics and some data collection and methodology). SMED will compile the 2000 GHG inventory for the first time and will deliver preliminary data to the EPA before 1 November each year. The linkages between the National Board of Forestry and the SMED consortium were not fully understood by the ERT.

2. Record keeping and archiving

22. A complete electronic version of the CRF and NIR for each year is kept on the computer network at the Swedish EPA. Hard copies of the CRF and NIR and some supporting documentation are also kept at the Swedish EPA as well as at the Ministry of the Environment. A complete set of activity data is kept by Statistics Sweden, except for data on LUCF sector which are kept by the National Board of Forestry and the Swedish University of Agriculture Sciences for forest inventory statistics.

3. Verification and quality assurance/quality control (QA/QC) approaches

23. During the visit, the ERT was told about internal QC procedures implemented for the 2001 inventory submission. The QA procedure with independent external review of the inventories, apart from the UNFCCC in-depth review process, has not yet been carried out. The ERT was informed that Sweden planned to improve its inventory system in the future, including by further elaborating how formal QA/QC procedures would be carried out when the IPCC good practice guidance was fully implemented.

4. Recalculations

24. The methodologies for calculations or calculations were partially revised for energy, industrial processes, agricultural soils and waste in the 2001 submission. Emissions for 1990–1998 were recalculated using the new methodologies and emission factors on the basis of new data and research. In accordance with UNFCCC reporting guidelines, Sweden included in its CRF and NIR, information on recalculations covering the time series.

5. Uncertainties

25. A thorough assessment of uncertainty was not performed in the 2001 submission for most sectors. In keeping with the IPCC good practice guidance, the EPA inventory team had filled in the CRF table 7 with a qualitative estimation of uncertainty levels “high”, “medium” and “low” on a gas-by-gas basis approach, except for categories sign-posted with standard indicators “NE”

and "IE". However, some information on uncertainties of activity data and thresholds were provided to the ERT during the visit. The NIR also states that the uncertainty is largest for the inventories of NMVOC, CH_4 and N_2O (perhaps with an uncertainty factor of two), while the uncertainty for the CO and NO_X emission estimates is assumed to be less than 30 – 40% and the uncertainty for CO_2 may be as low as 1 – 2%.

6. Issues related to previous reviews

26. The Swedish inventory was last reviewed as part of the in-depth review (IDR) process for the Second National Communication. National inventory experts did not address any special issues or problems identified during the IDR, but they clearly stated that many significant improvements had been achieved over the past three years. Improvements had been incorporated in the 2001 inventory submission and relevant recalculations had been provided.

27. The S&A report noted a number of issues that needed explanation in the Swedish inventory. Sweden generally provided adequate explanations for the issues raised. Specific comments on outstanding issues from the S&A report are noted below under the relevant sectors.

7. Areas for further improvement

Planned or ongoing work by the Party

28. The NIR identified several areas for further improvement. The EPA said that it intended to improve the part of the inventory dealing with non-CO_2 emissions from the transport category, particularly for road transport, off-road vehicles, railways and navigation sources. In addition, it is prepared to improve the calculations of biomass burning in the residential sector, and generally in solvent and other product use, as well as in the agriculture sector (specifically methane emission factor from enteric fermentation). Issues related to notation and minor emission sources would be addressed.

29. The newly established SMED system is expected to bring about a significant improvement. Responsibility for data base construction, geographical distribution, emission factors, methodology and for data collection and statistics will be unequivocally shared between SMHI, IVL and Statistics Sweden. Such an approach could make a positive contribution to the quality and transparency of future submissions. The newly established institutional arrangements will be evaluated in 2002. The role of the National Forestry Board still needs to be clarified.

Issues identified by the ERT

30. The ERT identified the following major areas for improvement related to cross-cutting issues in the Swedish inventory:

(a) to analyse the uncertainty of the estimates and its attribution to different factors;

(b) to provide a more precise description of methodologies that differ from the IPCC's;

(c) to make arrangements for more QA/QC, including possible external QC;

(d) to strengthen communications (with provision for feedback) between the EPA and the agencies supplying data, as well as methodologies to allow for a more integrated inventory preparation process. Significant improvements are expected from the implementation of the SMED.

F. Conclusion

31. The ERT considers that Sweden provided adequate information to the COP on its GHG inventory and GHG emission trends. The ERT also noted that the inventory has improved over the last year and is confident that it will continue to improve in the future.

II. ENERGY

A. Sector overview

32. Fossil fuel combustion is the largest sector in the Swedish GHG inventory. In 1999, emissions from fossil fuel combustion contributed more than 80% of Sweden's total GHG emissions. At a good practice level, the key source categories in the energy sector included CO_2 emissions from stationary combustion of coal, oil and gas for energy production, heating, manufacturing, and emissions from mobile sources in road transport (see Table 3).

33. In 1999, road transport accounted for 28% of total national emissions, energy production and heating for 19% and manufacturing for 17%. During the period 1990 to 1999, emissions remained essentially the same, with temporary increases in 1994 to 1996.

1. Institutional arrangements

34. The Swedish EPA is responsible for compiling and archiving the inventory for the entire energy sector. It also carries out some quality control. Statistics Sweden prepares the energy sector estimates including emissions of both CO_2 and non-CO_2 gases. Input data for the sector are provided by the energy division of Statistics Sweden, the national aviation, navigation and railways administration authorities, and major companies and fuel wholesalers.

2. Completeness

35. The ETR noted that greenhouse gases from the majority of source categories in the energy sector were reported, with a few exceptions such as CH_4 and N_2O emissions from railways, oil and natural gas systems and international bunkers. Emissions of other gases (CO, NO_X, NMVOC and SO_x) were also provided. The CRFs for the 1990 to 1999 period included all required tables in accordance with the UNFCCC reporting guidelines. The CRF table 8 (recalculations) provided updated estimates for the entire time series (1990 to 1998). When no numerical data were reported, notation keys (IE, NO and NE) were used.

3. Transparency

36. The ETR noted that the NIR lists the net calorific value of each fuel and the emission factors used in the estimation of GHG emissions. The NIR also provides the data sources for fuel consumption, emission factors and net calorific values.

37. The NIR does not provide a detailed explanation of the methodology used for estimating GHG emissions, the methods used for developing emission factors or procedures for collecting activity data for the sector. However, during the visit the Swedish experts explained existing procedures to develop emission factors to the ERT.

38. Based on the information provided, the ERT assessed that transparency was satisfactory but that there was room for improvement, especially with respect to issues related to a more transparent presentation of methodologies and emission factors in the NIR. The ERT also noted

that it would be useful to provide in the NIR summary results of GHG emissions from the energy sector, which could complement data reported in the CRF and contribute to transparency.

4. Methodologies, emission factors and activity data

39. Sweden used a combination of three approaches to estimating GHG emissions from the energy sector:

(a) CO_2 and non-CO_2 emission estimates from stationary combustion and mobile sources (with the exception of diesel) were based on the IPCC tier 1 approach (reference and sectoral approach);

(b) CO_2 and non-CO_2 emissions estimates from mobile sources (diesel) used IPCC tier 2 method (through use of a model);

(c) non-CO_2 emissions for aviation, navigation and railways from information provided in legal environmental reports submitted by the national authorities.

40. All the emission factors used in the Swedish energy inventory are country-specific. They are provided by the Swedish EPA and Statistics Sweden and are based on measurements and national studies as well as studies from international sources. The Swedish experts said that the emission factors for non-CO_2 emissions were last assessed in 1996 and were due for revision.

41. Thermal values (net calorific value or NCV) were calculated on the basis of the chemical properties and were assessed by both the ERT and Swedish experts to be accurate. However, it was noted that the NCV for coal, coke oven gas and blast furnace gas varied for different years due to different /dynamic operating conditions at the sources.

42. For the reference approach, CO_2 emissions were estimated from energy balance sheets prepared by Statistics Sweden from data collected by fuel wholesalers/suppliers and consumers. For the sectoral approach, GHG emissions were estimated from comsumption statistics obtained from the same sources. The data was assessed by both the ERT and the Swedish experts to be reasonably accurate.

5. Recalculations

43. The ERT noted that recalculations of the time series 1990–1998 had been undertaken to take account of adjustments in methods, emission factors and activity data. The rationale for these changes is provided in the NIR.

6. Uncertainties

44. Although quantitative estimates of uncertainties for the activity data, emission factors and emissions were not calculated, a qualitative assessment was applied to the error range of source data. The ERT noted that there is a need to calculate estimates of uncertainty in accordance with the provisions of the IPCC good practice.

45. According to the Swedish experts, among the three data sources for the energy sector, namely energy balance, monthly reports and environmental reports, the monthly reports tended to be relatively more accurate where data for mobile combustion was concerned.

7. Verification and QA/QC

46. The NIR indicated that some QC was performed in the preparation of the inventory, but it did not elaborate on what procedures were actually implemented. The NIR further states that neither the QA nor independent verification was implemented. The ERT was informed that verification of the energy sector inventory was conducted by the Swedish EPA and that a QA/QC assessment would be undertaken for future inventory reports.

8. Consistency with the IPCC and UNFCCC reporting guidelines

47. The Swedish GHG inventory has been prepared in accordance with the requirements of the IPCC guidelines, and emissions estimates have been provided using the CRF tables.

9. Reference and sectoral approaches

48. A comparison was undertaken of the energy consumption and CO_2 emissions reported under the reference and sectoral approaches. CO_2 emissions differed by –2.67% to 2.93%. The difference exceeded 2% for two years only (1990 and 1995). The Swedish experts indicated that the small difference is an indicator of the reliability of the activity data and emission factors used.

49. Sweden is examining the potential risks from double-counting of carbon in the energy inventory. To avoid this, special consideration was given to blast furnace and coke oven gases and black liquor. In the iron and steel industry, emissions arising from combustion of blast furnace and coke oven gases were reported under energy, whilst those from the process were considered under industrial processes. Black liquor was considered as an energy source in the energy balance of the pulp and paper industry, since this residue is consumed for heat and electricity generation.

B. Key sources

1. Approaches

50. Sweden performed a key source analysis for the energy sector using IPCC methodology based on level and trend criteria assessment. The methodology involved determination of a single fuel in a single sector. Based on this approach, only activities relating to CO_2 emissions from energy and industrial processes and corresponding subcategories, were considered. In the NIR, however, there is no description of the assessment procedures. To further enhance its key source analysis, Sweden intends to apply the level and trend criteria assessment in accordance with the IPCC good practice guidance taking into account other GHGs, sectors and subcategories. For the purpose of this report, the ERT used the secretariat's approach for key source analysis (see paragraphs 10 –12).

2. Stationary combustion – CO_2 emissions from gas, coal and oil

51. In 1999, the contribution of stationary combustion from subcategories energy industries, manufacturing and construction was 31% of total national GHG emissions. Between 1990 and 1999, emissions from these sources remained essentially the same, with occasional increases between 1994 and 1996. In 1996, the contribution of stationary combustion increased to 40% while in 1999 emission levels fell back to those of 1990.

52. CO_2 and non-CO_2 emission estimates from stationary combustion were based on the IPCC tier 1 method with activity data drawn from the energy balance and monthly reports. The Swedish experts informed the ERT that despite the changes that had taken place in the way

activity data are collected, the surveys are considered to give high quality information and the possibility of mistakes is marginal.

53. The ERT was also informed that for category 1.A.4 (except for energy consumption in households) fuel consumption had been estimated with the aid of models and extrapolations, which affects the quality of the emissions estimates. Although total consumption is checked against fuel deliveries, errors may occur in the allocation to the different sectors.

3. Mobile combustion – CO_2 emissions from road vehicles

54. CO_2 emissions from road vehicles increased by 9.7% over the 1990–1999 period. The contribution of road transport to total national GHG emissions increased from 27% in 1990 to 29% in 1999.

55. CO_2 and non-CO_2 emissions estimates from mobile sources were calculated with the aid of a model (EMV). The emissions estimates were based on traffic data, description of different vehicle categories, description of different fuel types, emission factors for cold starts and hot emissions, evaporation rates, deteriorating factors, engine technology, different modes of driving (rural/urban/highway) and other parameters.

56. The EMV model was used to calculate emissions of all gases for the years 1995 to 1999, while for the years 1990 to 1994, an older model (no separation between gasoline and diesel oil) was used to estimate emissions of CH_4, N_2O, NMVOC and SO_2. The use of the different models has resulted in emissions estimates that are not comparable across the whole time series (1990 to 1999). The Swedish experts indicated that future revisions of the inventory would address this issue.

57. The Swedish experts explained to the ERT that the amounts of diesel oil used for calculating emissions had been "corrected" in order to eliminate annual fluctuations that are thought to be due to storage of diesel oil by consumers during periods before an increase in the fuel price. This has resulted in a smoothed-out curve for all emissions from diesel oil usage. The ERT commented that this approach is not in accordance with the IPCC good practice guidance and suggested that future inventories do not include any such corrections.

4. Mobile combustion – CO_2 emissions from aircraft

58. Emissions from aircraft contributed 1.41% to total emissions in 1999 compared with 1.49% in 1990.

59. The division between domestic and international flights is based on calculations from the Swedish Civil Aviation Administration. Landing and take-off cycles are considered in accordance with the IPCC good practice guidance.

5. Fugitive emissions from oil and gas operations

60. Fugitive emissions amount to only 0.53% of total emissions and were reported mainly as coming from gas transmission losses in the pipelines and flaring.

6. International bunkers

61. In accordance with the IPCC Guidelines, emissions from international bunkers for aviation and navigation were calculated but were not reported as part of total energy emissions.

62. Information on emissions from navigation and their division between domestic and international marine operations has been collected from the Swedish Maritime Administration. The quality of the calculated emissions is considered to be representative for this sector, but the division into national and international operations is approximate and not well documented. The Swedish experts indicated that they will address this situation in the future.

7. Other sources

Navigation

63. Emissions estimates of non-CO_2 gases from shipping were determined by a model developed for the National Administration for Shipping and Navigation. The ERT observed that there is inconsistency between estimates of CO_2 and estimates of non-CO_2 gases because different activity data were used for these calculations. The Swedish experts took note of this and informed the ERT that it would be addressed in future submissions.

C. Areas for further improvement

64. The ERT identified the following areas for improvement specifically related to energy sector of the Swedish inventory:

(a) to up-date emission factors for non CO_2 emissions;

(b) to analyse the uncertainty of estimates and how it is attributed to different factors;

(c) to recalculate transportation emissions time series to take account of the new model (EMV), which separates gasoline and diesel;

(d) to verify and update emission factors from crude oil under the reference approach; and

(e) to reconcile activity data in the navigation sector for non-CO_2 emissions.

III. INDUSTRIAL PROCESSES AND SOLVENTS USE

A. Sector overview

65. Industrial processes (IP) contributed 8.6% of total Swedish GHG emissions in 1999 and were responsible for five of the 21 key sources identified by the UNFCCC secretariat (see table 3). The sector accounts for 100% of emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

66. Emissions from IP increased by 27% from 1990 to 1999. The main increase of 25.9% took place from 1990 to 1995. Since then emissions have stabilized at the 1995-level, and only increased by 2.7 % during the last year. The time series is consistent for CO_2 emissions but not for non-CO_2 GHG emissions. Sweden described plans for further improvements to the inventory for this sector. The ERT was provided with sufficient proof that these improvements would be forthcoming.

67. In addition to the above mentioned key sources, Sweden produced estimates of GHG emissions from lime production (CO_2); other mineral products (CO_2 and N_2O); aluminum production (CO_2); other metal production – non-ferrous (CO_2); and magnesium foundries (SF_6).

1. Institutional arrangements

68. Statistics Sweden is responsible for estimating CO_2 emissions from this sector. The Swedish Environmental Research Institute (IVL) estimates other GHGs and their precursors. EPA Sweden is responsible for compilation and submission of the inventory to the UNFCCC as well as for improving the methodology for estimating emissions.

2. Completeness

69. The Swedish inventory covers almost all subcategories of industrial processes except for a few cases where emissions were not estimated. The omissions are solvents and SF_6, which is not used as a trace gas for clinical purposes in Sweden.

70. In some cases (e.g., in table 2.F.5 of the CRF) notation key NE was not used. Indirect emissions of CO_2 (oxidized CO_2) from CH_4 and NMVOC were also not included in the emissions from IP. This should have been indicated using notation key NE in the relevant cells in the CRF tables.

3. Transparency

71. The transparency of information provided in the NIR and CRF leaves room for improvement. Information provided in the NIR does not back-up sufficiently the data provided in the CRF. Apart from the model used for calculating HFC gases, the methodology and emission factors for other subcategories are not sufficiently documented in the NIR and a reference list is not provided to complement the description of the methodology and emission factors.

4. Methodologies, emission factors and activity data

72. The methodologies applied for emission estimations in this sector are generally consistent with IPCC Guidelines and the IPCC good practice guidance. Sweden used country-specific emission factors. Activity data were obtained from industrial statistics and from private companies through reporting. Emissions of CO_2 were calculated from production data and consumption of raw materials. N_2O, CH_4 and PFCs from aluminum were estimated on the basis of production data or data from corporate environmental reports. HFCs and SF_6 were calculated using tier 2 methods, and the methodology is well documented in the NIR. Apart from the model for calculating HFC gases, the methodology and emission factors for other subcategories are not sufficiently documented.

5. Recalculations

73. Since the 2000 submission, emissions from almost all IP sources and all gases except FC-gases have been recalculated for the years 1990–98. As a result of the recalculations, the CO_2 emissions from IP decreased by about 10% in 1990 and increased by 29% in 1996; for other years the recalculations yielded changes within this range. The recalculations of CH_4 and N_2O resulted in only minor changes in the emissions.

74. Recalculations are explained in the CRF or the NIR, although it was noted that annual recalculations were only provided for 1998, 1997, 1996 and 1990 in CRF table 8(a). According to CRF table 8(b), emission factors and activity data were changed in 1998 as well as in other years, but the nature of changes was not specified. For 1994, table 8(b) indicates that emissions were recalculated, but the specific sources are not indicated in table 8(a). Although it was not

easy for the ERT to find out whether and how the recalculations had improved the quality of the inventory, based on explanations by the Swedish inventory experts it can be concluded that real improvements were made.

6. Uncertainty estimates, verification and QA/QC approaches

75. Estimation of uncertainties in the calculations has not been provided. Sweden has not implemented any verification or QA/QC procedures for industrial processes. The ERT was informed that Statistics Sweden and IVL had conducted internal checks of the emissions and activity data, such as comparison with previous data. However, the ERT noted, for example, that there was no procedure for comparing the energy data used in the calculation of IP emissions with relevant data from national energy accounts.

B. Key sources

1. Cement production – CO_2

76. CO_2 from cement production accounted for 1.7% of national total GHG emissions in 1999. The emissions have decreased by 2.0% since 1990.

77. Sweden estimated CO_2 emissions from cement production using data on limestone reported by industry and a country-specific emission factor. The emission factors used in the inventory were not documented in the NIR, but were reported to ERT on request.

78. According to the draft S&A report for 2001, Sweden was the only country to use this approach. This methodology is neither tier 1 based on cement production, nor tier 2 based on clinker production. Consumption of limestone is provided in the background table and the calculated IEF is not comparable with the IEFs used in other countries. Having analysed data on clinker production provided by Statistics Sweden and IPCC's default emission factor, the ERT found that Sweden had overestimated CO_2 emissions from cement production by 15–18% compared with IPCC's tier 2 method.

79. Since this is a key source according to both the level and trend analyses, the ERT recommends that the calculations are brought more into line with the IPCC tier 2 method.

2. Nitric acid production – N_2O

80. N_2O from nitric acid production contributed 1.3% of national totals of GHG in 1999. The emissions have decreased by 1.2% since 1990. It is a key source according to both the level and trend analyses.

81. Swedish experts informed the review team that N_2O emissions were measured from two to four times a year. They defined the method for estimating emissions from this source as tier 2. Production data of nitric acid were not included in the CRF table, although the data from 1997 to 1999 were provided by Sweden in its response to the S&A report for 2001. The ERT was informed that the data for 1990–1996 would be submitted in the 2002 NIR.

3. Iron and steel – CO_2

82. CO_2 from production of pig iron accounted in 1999 for 2.9% of total national GHG emissions. According to the CRF, emissions have increased by more than 80% since 1990. It is a key source in both the level and trend analyses.

83. The emission estimates were based on the consumption of dolomite reported by industry. Sweden did not document the emission factor used for the estimates, but it provided the relevant information to the ERT during their visit. The S&A report noted that activity data for this sector were an order of magnitude larger in the United Nations' data than in the Swedish CRF. In response, Sweden stated that the discrepancies had occurred because the CRF provided data on dolomite consumption while the United Nations published production data.

4. Ferroalloys – CO_2

84. CO_2 from production of ferroalloys contributed 0.5% to Swedish GHG emissions in 1999; the emissions have increased by 0.3% since 1990. This is a key source according to the trend analysis.

85. Sweden estimated CO_2 emissions using data on coke consumption and a country-specific emission factor, which was not documented. Consumption data were obtained from the industry.

86. The S&A report for 2001 informed Sweden that the IEF in this category was high compared to other countries. Sweden did not provide any explanation for this in its response to the S&A report. However, during the visit, Swedish inventory experts provided the ERT with detailed information on how the emissions were calculated. The ERT noted however, that this method suggested that C binding in products was too high. Therefore, the ERT recommended Sweden to review the methodology for calculating CO_2 emissions from this IP category.

87. The CRF tables suggest that CO_2 emissions have increased by more than 50% from 1990 to 1999. Sweden indicated that incorrect activity data may have been used.

5. Aluminium production - PFC

88. Emissions of PFCs from aluminium contributed 0.5% to the national total. This is a key source in the trend analysis. Due to the implementation of new measures in this industry, PFC emissions decreased during the period 1990–1999.

89. The ERT was informed that emissions had been estimated on the basis of the tier 2 methodology. The ERT noted that references to data on the emissions factor and aluminium production were not provided in the NIR; Sweden indicated that for reasons of confidentiality these data may not be published.

6. Consumption of HFCs, PFCs and SF_6

90. In 1990, this source contributed 0.1% to total national GHG emission. By 1999 it had increased its share to 0.7% of the national total. It is a key source according to both the level and trend assessments. Actual emissions of HFCs, PFCs and SF_6 were reported for all years for 1990–1999, while potential emissions were reported for 1995–1999 only due to the lack of data for earlier years.

91. Sweden applied a tier 2 methodology for estimating emissions of FC gases. The ERT was provided with a description of an Excel based model published in a report bys the IVL.

92. The lifetime of equipment and emission factors (leakage time) for different applications using HFCs and/or SF_6 was not clearly documented in the NIR, but references were made available to the ERT during their visit.

93. The ERT was able to examine all the data from gas manufacturers and distributors, equipment manufacturers, end-users and trade associations required for applying tier 2. The consumption of chemicals by large (more than 10 kilograms capacity) stationary refrigeration /AC equipment is reported to the Swedish EPA. Data on bulk imports and exports of chemicals as provided by the Swedish Chemicals Inspectorate, are based on annually reported amounts from trading companies.

94. Country-specific emission factors, which are in line with the IPCC default emission factors, were used to calculate emission estimates. The ERT noted that the issue of how trade statistics might improve the model outputs needs to be investigated and elaborated in order to improve the quality of the inventory.

95. The draft S&A report for 2001 notes very high potential-to-actual emission ratios in 1999 for several HFCs used in Sweden's inventory. Sweden's response is that since the calculation of potential emissions is based on information from two independent sources (trade statistics and the sector-based emission inventory), the discrepancies may be due to incorrect data in either of the two sources, i.e., an underestimate of actual emissions or incorrect trade statistics.

96. No activity data were reported for HFCs in the CRF or the NIR. Sweden stated that the CRF table was not suited to national circumstances since its own subgroups for HFC emissions differed from those in the CRF. Sweden considered that amalgamating [?] its subgroups to fit into the CRF format would lead to more uncertainties in the HFC emissions estimates.

97. The ERT noted that from 1990 to 1993 emissions from aerosols and metered inhalers were reported as NE because the data were not available. Later investigations indicated that HFC's had been used in metered dose inhalers from 1996–1999 and emissions were about 0.1–0.15 ton of HFC-134a. The ERT recommended that Sweden include the missing data in its inventory.

C. Non-key sources

1. Lime production – CO_2

98. The CO_2 emission estimates were based on consumption of CaO and an emission factor of 0.771 ton CO_2 per ton CaO. The method complies with IPCC good practice guidance. Emissions of CO_2 were estimated at about 0.3 million tonnes in 1999; they had been at the same level since 1990.

2. Aluminium production – CO_2

99. According to information given to the ERT, calculation of CO_2 from aluminium production was based on consumption of reducing agents reported by industry. This method is in line with the guidelines, although the emission factor was not documented. Annual emissions were estimated to be about 0.2 million tonnes CO_2 over the period 1990–1999.

3. Other metal production – non-ferrous – CO_2

100. CO_2 emissions from copper production were estimated in this category. The emissions calculation was based on data on consumption of reducing agents reported by industry. The method is in line with the IPCC good practice guidance.

4. Magnesium foundries – SF_6

101. Two Swedish magnesium foundries have been using SF_6 instead of SO_2 as a cover gas since 1993. The ERT was informed that the SF_6 emissions from magnesium foundries increased about 1.7 times from 1993 to 1999. The calculations are based on consumption information from one plant, which is in line with IPCC good practice guidance. The trade statistics on imported SF_6 used as a reducing agent are detailed, and were used in combination with information from the reporting company to calculate the national figure. The ERT advises Sweden to collect data from all plants which use SF_6 when reporting emissions in this category in future submissions.

5. Other mineral products – CO_2 and N_2Os

102. CO_2 emissions were estimated from the production of glass and mineral wool. Calculations of CO_2 emissions were based on consumption of raw materials reported by the industry and a country-specific emission factor. N_2O emissions from the production of explosives were estimated using the CORINAIR emission factor. The method is in line with the guidelines.

D. Areas for further improvement

103. Transparency and verification are the main issues in this sector. We would encourage Sweden to describe its methodology in general and particularly the methodology used by companies to estimate emissions, especially from key sources. This will improve transparency and make it easier to review the methodologies used in the inventory.

104. It would be useful if country-specific emission factors were to be compared with IPCC default factors and any large differences explained in the NIR.

105. The ERT believed that if one institution were responsible for compiling emissions data from industrial processes for all gases, this could improve verification of the data – for example, activity data from companies could be compared with national totals – and eventually help to improve the quality of inventory.

IV. AGRICULTURE

A. Sector overview

106. In 1999, agriculture accounted for 16.6 % of total national emissions, 58% of total N_2O emissions and 55% of total methane emissions. There is no obvious trend in annual emissions which fluctuated by less than 4% around the mean of about 7,779 Gg CO_2 eq. during the 1990–1999 period.

1. Methodologies, emission factors and activity data

107. The ERT was provided with a comprehensive list of data sources during their visit. In addition to the Swedish Farm Registry, updated annually through surveys carried out for the Swedish Board of Agriculture, some ad-hoc surveys are conducted by Statistics Sweden at intervals to supplement the standard information. Production data are obtained from industry associations. Statistics Sweden also performs and uses the output from model-based simulations to generate soil nutrient concentrations and flows, ammonia emissions and N-fixing rates in

hayfields, using models developed by the Swedish University of Agricultural Sciences, the Board of Agriculture and Statistics Sweden itself.

108. Emission factors used were either adopted from the IPCC, developed from model results or drawn from studies. From discussions with Swedish experts, the ERT learned that emission factors were chosen by the EPA on the basis of a review of the relevant literature (which can be quite extensive) and after discussions with scientists and experts. Because the EPA has little control over research activities in the agriculture sector, the process for improving emission factors through research activities is uncertain.

2. Completeness

109. All the IPCC source categories and GHGs are covered in the agriculture sector, except for those which do not occur in Sweden and these are generally indicated.

110. Two manure management systems are reported in table 4B(b): liquid system and solid storage/dry lot. The S&A report for both 2000 and 2001 mentioned missing information on other management systems in the table, and Sweden replied that it did not consider N_2O emissions from excretion of grazing animals (reindeer) a manure management system. Direct N_2O emissions from soils due to the application of animal wastes to soil were reported in table 4.D. This clarification could be provided in the NIR and the appropriate notation entered in the CRF.

111. The report provides emission estimates for a new source: background emissions of N_2O from the cultivation of mineral soils. While the NIR provided a clear description of the calculation procedures, it omitted to include the rationale for incorporation this new source.

3. Transparency

112. The ERT noted the high degree of cooperation shown by the Swedish technical experts and the abundance of information readily provided. Clarification of a number of issues was offered to the ERT which could have been included in the NIR, for example, a discussion of different trends and their underlying causes.

113. The NIR states clearly that the IPCC methodology was used, supported by data from official Swedish statistics, which were further detailed in the appropriate sections of the report. While the general IPCC approach was used, in some instances estimates from specific sources were calculated with country-specific methodologies developed by Sweden. This was the case with methane from enteric fermentation in cattle, N_2O emissions from hayfields, background N_2O emissions from the cultivation of mineral soils and indirect N_2O emissions from leaching.

114. Country-specific emission factors were used for the most significant sources. The ERT noted the transparent use of emission factors: the NIR contains a comparative table of five new national N_2O emission factors from agricultural soils, and the corresponding default IPCC values. The emission factor for background N_2O emissions from cultivated mineral soils was also reported. All these new factors were taken from a study which, at the time of the review, had not yet been published, and no explanation was provided in the NIR on how they had been calculated. The study has recently been published in Swedish.

115. The ERT found that the derivation of country-specific emission factors was not sufficiently documented. For example, information was lacking on the process used to obtain methane emission rates from enteric fermentation in cattle, the major component of the largest

key source in the agricultural sector. The method currently in use, listed in the references, was said to be deficient and has been under revision since the 2000 submission. Wherever possible, a clear description of national methodologies and the derivation of country-specific emission factors would improve the transparency of the NIR. The use of model outputs should be backed up by general information on model input data, modelling approaches and assumptions, as well as an analysis of outputs in terms of relevant variables.

116. The ERT noted that emission factors were very well documented: the NIR contained a useful tabulated summary of emission factors, their values and references.

4. Recalculations

117. Recalculations for the following categories and gases were performed for the 2001 submission: CH_4 from enteric fermentation and manure management, N_2O from agricultural soils and manure management. These emissions were recalculated for the period of 1990–1999. The nature of the changes is explained in the CRF table 8(b).

5. Uncertainty estimates, verification and QA/QC approaches

118. No uncertainty analysis is performed for the inventory. The NIR acknowledges the uncertainty associated with the generalization of research findings.

119. There is no formal procedure for QA/QC control.

6. Consistency with the UNFCCC reporting guidelines and the IPCC Guidelines

120. Based on the information received during the visit, the ERT confirms that the inventory of GHG emissions in the agriculture sector generally complies with the reporting guidelines and good practices. It was noted, however, that the rationale for emission factor selection should be better documented in the NIR.

B. Key sources

121. The secretariat identified the following key sources (see Table 3) in the agricultural sector: CH_4 from enteric fermentation in domestic livestock (4.4% of national totals); direct N_2O emissions from agricultural soils (3.2% of national totals); N_2O from category "Other", including agricultural soils, cultivation of mineral soils and N-fixation in hayfields (1.1% of national totals); N_2O emissions from manure management (0.9% of national totals) and N_2O from animal production (0.7% of national totals).

1. Methane emission from enteric fermentation

122. Methane emission from enteric fermentation, the most important key source in the agriculture sector, contributed approximately 4.4% to national totals and 84% to emissions in the agriculture sector in 1999. This is a key source in both the trend and level assessments. Emissions by cattle accounted for almost 90% of the total methane emission from enteric fermentation.

123. The trend over the entire series indicates a 22% decrease in methane emission from enteric fermentation. As explained during the in-country visit, the general decrease in methane

emission from enteric fermentation in cattle was associated with a corresponding reduction in the domestic cattle population.

Methodology, activity data and emission factor

124. In Sweden's inventory, methane from enteric fermentation was estimated using either a national methodology (dairy and non-dairy cattle and reindeer) or the tier 1 methodology based on default emission factor values for less significant animal groups (swine, sheep, goat and horses).

125. Statistics for activity data used in the estimation are well referenced. Data on animal populations are obtained from the National Farm Registry and include age-class distribution, with the exception of chicken slaughter data which is provided by the Poultry Meat Association.

126. The emission factors used in the estimation of methane emission from enteric fermentation are not fully referenced. A single emission factor for dairy cattle (154 kg/hd/yr) is used for the entire reporting period. This value is much larger then the IPCC default emission factor or that of other Annex I Parties, including other Scandinavian countries. Swedish experts indicated that this value had been considered to be more representative of conditions in Sweden. The ERT learned that recent research findings could lead to a further revision and lowering of the emission factor. Swedish experts indicated that joint research activities were planned in cooperation with EU countries and especially Scandinavian countries, in order to develop emission factors relevant to common climatic conditions and similar agricultural practices. The emission factor has been under review since 1999 and full recalculations will be provided in future submissions.

2. Direct N_2O emissions from agricultural soils

127. Direct emissions of N_2O from agricultural soils, the second most important key source, contributed 3.2% to the national total and about 7% to emissions from the agriculture sector in 1999. The largest subcategory sources are the application of animal wastes and mineral fertilizers to soil.

128. There is no discernible trend in direct N_2O emissions from agricultural soils.

129. N_2O emission estimates have been provided for all the subcategories under this source. Nitrous oxide emissions from animal excretions on pasture range are included in this source category but not in manure management systems, hence the discrepancy noted in the 2000 and 2001 S&A reports between total N excretion by animal populations and that compiled from animal waste management systems.

Methodology, activity data and emission factor

130. In general, the IPCC methodology was used with country-specific emission factors. The NIR description of the methodology refers to CORINAIR ammonia-N emissions associated with fertilizer application, which belong to the subcategory of indirect N_2O emissions from deposition. There is no clear description of the methodology used for derivation of N_2O emissions from animal wastes in the NIR.

131. Data on fertilizer sales, as well as on farm areas under various crops, are collected annually by Statistics Sweden. Manure production by dairy cattle is derived from milk production data, using coefficients developed by the Swedish Board of Agriculture. While the

NIR stated that milk production data are of a high quality, the derivation of coefficients is not fully documented apart from one reference. Manure production by cattle and swine is derived from a research-based model (STANK) developed at the Swedish University of Agricultural Sciences. The NIR mentioned the uncertainty associated with generalization in the research findings.

132. Data on the fraction of manure solid storage are collected annually by Statistics Sweden. Stable periods for cattle populations have been observed since 1997, collected within the biannual survey on manure management; prior to this period, national standard values were used.

133. The 2001 S&A report noted that the implied emission factor for fertilizer application is among the lowest across reporting Parties (0.0079), while those used for animal wastes are among the highest. The derivation of these factors is not documented in the NIR. However, the Swedish experts demonstrated to the ERT that a comprehensive review of the literature had been conducted on the subject which could provide input to the IPCC good practice guidance and improve the IPCC range of default values presented there.

3. N_2O from the cultivation of mineral soils and N-fixation in hayfields

134. This key source, the third most important in the agriculture sector, accounted for 7% of the national total and 18% of nitrous oxide emissions from the agricultue sector in 1999. Of the two subcategory sources, the cultivation of mineral soils contributed approximately 80% of N_2O emissions.

135. There is no apparent trend in emissions from this source.

136. The two sub-sources are country-specific, hence there is no reporting requirement under the guidelines.

Methodology, activity data and emission factor

137. There is some uncertainty regarding the category to which these sources belong. The NIR includes them under direct N_2O emissions from agricultural soils, whereas, owing to formatting constraints in the CRF, they are listed there under the category “Other”. The two sources listed under this category are not defined in the NIR in a way that would help distinguish them from other direct or indirect N_2O emissions from agricultural soils. Without this information the ERT was unable to assess the relevance of these sources from a methodological point of view. The general approaches used were similar to the IPCC default.

138. An ad-hoc survey conducted by Statistics Sweden in 1998 provided the information needed to divide the total area of arable land into mineral and organic soils (91% and 9% respectively). The area of hayfields in each Swedish county is available, and the rate of N fixation in leys is derived from the output of the NPK-FLO model of the Swedish University of Agricultural Sciences.

139. In the NIR a country-specific emission factor for N_2O emissions from the cultivation of mineral soils, 0.5 kg N_2O-N/ha, was provided without explanation. Sweden used the IPCC default emission factor associated with N-fixation.

4. Manure management – N_2O

140. This key source, the fourth largest in the agriculture sector, accounted for 0.9% of the national total and 14% of nitrous oxide emissions from agriculture. Nitrous oxide emissions from manure management decreased by 17% over the 1990–1999 period, in spite of increases in several excretion rates over the same period. The reduction occurred after a milk production quota was imposed following Sweden's entry into European Union in 1994. The NIR provides a detailed explanation of the range of the emission factor used in this category.

141. The emissions reported under this heading do not include N_2O emissions from excretions on pasture range; otherwise it would be third in importance among the Agriculture key sources. Swedish experts confirmed during the review that Sweden does not consider animal production of nitrogen from grazing animals as a manure management system, hence this source is accounted for as direct N_2O emissions from agricultural soils (see section 129).

142. N_2O emissions from anaerobic lagoons, daily manure spread, pasture range and paddock were reported as not occurring for the animal wastes management system (AWMS). Emissions of nitrous oxide from anaerobic lagoons in Sweden were found to be negligible.

Methodology, activity data and emission factor

143. Tier 2 methodology was used for the emission estimates from cattle and swine and tier 1 for other animal groups.

144. Manure production data are collected or estimated as described above under direct N_2O emissions from agricultural soils.

145. The 2001 S&A report noted that the N-excretion rate for dairy cattle (118kg N/hd/yr) is the highest across all reporting. Conversely, rates for non-dairy cattle, sheep, swine and poultry were among the lowest values reported by Parties. The estimate for swine (8.64kg N/hd/yr) and sheep (5.76kg N/hd/yr), in particular, are far below the IPCC default value of 20kg N/hd/yr. Excretion rates are not discussed in the NIR, which only provides total N produced by various animal groups. Sweden contended that estimates produced were weighted averages of subcategories and the mix of animals recommended by the IPCC good practice guidance might lower the average N-production.

146. The ERT noted that analysis of the observed emission trends in terms of excretion rates, total animal populations, the breakdown between animal groups and age-class distribution would provide a useful insight and improve the transparency of the NIR.

C. Non-key sources

147. Two non-key sources were identified by the ERT for which more information should be provided: methane emissions from manure management and indirect N_2O emissions from agricultural soils.

148. The implied emission factor for methane emissions from manure management of non-dairy cattle used by Sweden was approximately three times lower than the IPCC defaults for cool-western Europe: this discrepancy should be acknowledged in the NIR, with an appropriate explanation.

149. Trends in the emission factor from dairy cattle increased by 38% from 1990 to 1999. The Swedish experts explained that manure production from dairy cattle depends on milk productivity, which had increased over the period. The emission factor for non-dairy cattle decreased by 9.8% in the same period, while for swine it increased by about 60% between 1990 and 1999. The ERT was informed that this latter trend was due to an increased proportion of swine for meat production.

150. The 2001 S&A report noted that the implied emission factors for atmospheric deposition and nitrogen leaching and run off are lower than the IPCC default values by one order of magnitude. The Swedish experts explained that the observed difference was due to use of national emission factors which were not documented in the NIR.

D. Areas for further improvement

1. Planned or ongoing work by the Party

151. The NIR indicated that improvements in CH_4 emission factors for the major source, were under way. The ERT was informed that joint work with other Scandinavian countries was under way in order to develop relevant emission factors.

2. Issues identified by the ERT

152. The ERT acknowledged the quality of the data used in preparing the inventory. It also recommended substantially enhancing the information provided in the NIR on country-specific emission factors and that, in particular, the various significant discrepancies between those and the IPCC defaults or the range of values used by Parties be addressed. Suggestions to improve the transparency of the inventory are provided under the appropriate heading above.

V. LAND-USE CHANGE AND FORESTRY

A. Sector overview

153. Sweden's LUCF inventory amounts to a large net removal of CO_2, approximately equivalent to over one third of total national emissions (without CO_2 from LUCF) and to 50% of this national total when net CO_2 emissions/removals are included. Carbon stock changes in forest and other woody biomass account for all the removals and are reported in the boreal forest category. Smaller CO_2 emissions are reported from the cultivation of organic soils and liming of agricultural soils. No other sources or sinks are reported.

154. During the 1990s, net LUCF removals fluctuated between 20 and 29 $MtCO_2$ per year with no apparent temporal trends.

1. Institutional arrangements

155. The Swedish EPA is responsible for the preparation of the inventory. A LUCF inventory has been produced since 1995.

Forestry

156. Calculations are carried out by the Swedish National Forestry Board. The Board's mandate is to support and implement all aspects of forest management, including the enforcement of related legislation.

157. The main data sources for the calculations are the national forest inventory statistics, published annually by the Department of Forest Resources and Geomatics of the Swedish Agricultural University at Umea (SLU), and which are public data. The Swedish national forest inventory also includes woodlots on agricultural lands.

158. The results of a model-based study conducted by the SLU faculty are used to estimate the expansion factor in order to convert stemwood to whole-tree biomass. Since 1983, the EPA funds additional soil data collection and analysis by the SLU. Additional data on forest fires may be obtained from the National Security Agency. Prior to submission, calculations and estimates are reviewed by staff at the National Forestry Board and by the EPA. Records of each submission are kept at the EPA's Environmental Monitoring Division.

Agricultural soils

159. Statistics Sweden produced the input data on area of cultivated organic soils and sales statistics of lime for agricultural and horticultural purposes. Estimates are developed at the Swedish Environmental Protection Agency, except for emission estimates associated with liming of agricultural soils, which are also prepared by Statistics Sweden.

2. Completeness

160. No estimates of non-CO_2 gases are reported. In its response to the S&A report Sweden explained that owing to the prohibition of forest drainage activities, methane emissions are assumed to be all natural. Swedish experts clarified that emissions from fires are insignificant because of very effective fire control measures. The response to the S&A report also recognized that some N_2O emissions may occur as a result of fertilization from anthropogenic N deposition, but at present the knowledge base is insufficient to allow any estimation.

161. Only the sectoral report and parts of table 5.D were filled in. Sweden has indicated that the other tables are not relevant to its national circumstances, but notation keys were not entered. Tables in the NIR report annual changes in forest carbon stocks for the 1990–1999 period derived using a national methodology. It would be helpful to have a clearer understanding of why the data required in table 5.A could not be derived from the values obtained with the Swedish methodology, as recommended in the Guidelines (reference manual, p. 5.16, box 4). An average annual stock change in the harvested wood product pool is also given in the NIR. It is mentioned in CRF table 9 that there are no statistics on forest conversion in Sweden and that very small areas (ca. 20 kha) of pasture and cultivated land have been abandoned over the last decade. However, the guidelines call for an assessment of land abandonment extending over the past 100 years (table 5.C). Sweden has indicated that the net change in C stocks due to land-use changes is included in total changes in forest C stocks.

162. Carbon changes in cultivated mineral soils are reported as nil, but no further explanation is provided.

3. Transparency

163. Since Sweden uses its own approach to produce estimates in the LUCF sector, a detailed description of the approach, the assumptions and the methodology is especially important in ordr to ensure transparent reporting.

164. The NIR clearly distinguishes between forests that are included and excluded in the inventory of forest biomass carbon stocks. It also identifies the major data source, the annual National Forest Statistics publication, although the actual statistics used as input data are not detailed. A stemwood to whole-tree biomass expansion factor was derived from a forecast study, referred to in a generic way as a "country-scale model study".[7] The basic parameters (for example, an average wood specific gravity) are generally provided.

165. Estimates of C stock changes in forests on a national scale are clearly presented in tables 5.1 to 5.3 of the NIR. The general approach and terminology, although fully described to the ERT during the visit, could be better reported in the NIR, along with calculation methods. Carbon in forest soils is not included in the reporting of stock changes, however, preliminary estimates of carbon removal or emission rates are provided for naturally well drained forest soils and previously drained peat soils.

166. The ERT found that CO_2 emissions from the cultivation of organic soils and the application of lime were well documented in the NIR.

167. Suggestions that would facilitate a better general understanding and improve the transparency of the NIR include:

(a) rationales for omitting or not reporting certain gases or certain potential sources;

(b) an overview of the methodology;

(c) definition of the terminology (such as what is included in "natural loss");

(d) description of the calculation methods;

(e) some key parameter values in models;

(f) discussion of trends;

(g) a list of references at the end of the section.

4. Methodologies

Forestry

168. Sweden applies its own methodological approach to the estimation of stock changes in forest biomass. The approach takes advantage of the large amount of detailed forest inventory data that have been systematically collected for several decades on more than 20,000 permanent sample plots. So far the LUCF inventory includes above ground and below ground biomass. Work is ongoing to include the soil C pool in the near future.

[7] A reference to one aspect of the study was given to the ERT: Petersson, Hans 1999. Biomassafunktioner för tradfraktioner av tall, gran och björk I Sverige. Swedish University of Agricultural Sciences.

169. The forest area inventoried consists of timber-productive, managed forest (22.9 million ha in 1990 and 22.6 million ha in 1996). Permanent sample plots on wood lots on agricultural and built-up land are also inventoried. Low-productivity forests are not inventoried.

170. Stand measurement data collected during an inventory cycle are compiled and aggregated to estimate total national C stocks in stemwood for the managed forests. Natural losses and fellings (harvested wood) are derived on an annual basis from the same inventory data. A national, aggregated estimate of average annual stemwood growth (in Tg C/yr) is calculated from tree-ring analyses over several years. "Opening" stemwood C stocks (Tg) are calculated directly from inventory data for the years 1990 and 2000; stocks for other years are obtained by adding growth and subtracting natural and harvesting losses. An internal consistency check was carried out by comparing the 1996 opening stock obtained at the end of the 1990–1996 time series with the value calculated from independent forest inventory statistics. The two values differ by less than 1% after correcting for the transfer of commercial forests to protected status.

171. C sequestered in branches, stumps and coarse roots is estimated at national level from the aggregated output of a model simulating stand biomass growth and allocation under various conditions and management options. The parameters, assumptions and input data of the model are not specified. The model results are used to develop an expansion factor to derive the increase in total tree biomass from changes in stemwood biomass during the 1990s.

172. The total increase in C stock in Swedish forest tree biomass between 1990 and 2000 is 75 Tg C, or 6.8 Tg C per year on average. Data are presented for coniferous and broad leaved species and broken down into stemwood biomass in the managed forest, stemwood of trees on other land, branches, stumps and coarse roots.

173. On the basis of preliminary data, forest soils appear to sequester 2–5 Tg C per year (net) from well-drained soils, while 1–3 TgC are lost annually as a result of peat oxidation in previously drained forest soils. Studies are in progress to improve the estimates of soil carbon stock changes.

174. A reduction of stock in managed forests was caused by the transfer in the early 1990s of approximately 0.25 million ha of managed forests to "preserved forests". This C stock "loss" was estimated roughly and added to the total managed forest carbon stock for the years following the transfer since it would otherwise imply equivalent C emissions.

175. Changes in the stock of harvested wood products, based on housing data, are estimated at 0.1 Tg C per year on average (NIR). However, the sectoral table reports 100 Gg CO_2, which is a different estimate.

CO_2 emissions from agricultural soils

176. The calculations of emissions from the cultivation of organic soils and liming are based on IPCC methodology and carbon conversion factors supported by national data on the rate of peat subsidence under crop cultivation, bulk density and the carbon fraction of the oxidized layer.

177. The calculations and rationale for the selection of parameter values are well described in the NIR and were supplemented by additional material during the visit.

5. Recalculations

178. Recalculations were conducted in the 2000 submission (1998 inventory year) after publication in 1999 of the results of the country-scale model-based study allowed the current expansion factor to be derived. The previous expansion factor had a value of 1.5, slightly higher than the current value of 1.23. Studies are in progress to further refine the way in which the expansion factor is derived.

6. Uncertainty estimates

179. No uncertainty estimates were provided in the NIR. Swedish experts indicated that a significant source of uncertainty is attached to the expansion factor. No error or uncertainty analysis was performed on the aggregation of model outputs. The ERT was informed, however, that Swedish forest inventory data is very precise: the standard error of stemwood volume data aggregated at the national level is less than 2%.

7. Verification and QA/QC approaches

180. Although quality assurance procedures are not formally implemented, informal consultations are held at the National Forestry Board and with the EPA to provide quality control through review estimates prior to submission.

181. Since the preparation of the LUCF inventory involves more than one agency or group, it may be appropriate to document quality control procedures that were mentioned to the ERT, such as internal data checks, and assess the need for additional measures among those listed in the IPCC good practice guidance document, such as checks for completeness and transcription errors.

8. Conformity with the UNFCCC reporting guidelines and the IPCC Guidelines

182. The guidelines recognize that countries with a highly developed commercial forestry industry may find it preferable to develop their own methodology for inventorying forest carbon stocks on the basis of national forest statistics. In that sense, Sweden's reporting of LUCF emissions and removals in the CRF and the NIR is generally consistent with the IPCC Guidelines. The Swedish methodology reflects the overall importance of forests in the national carbon budget. It may be appropriate to document the apparent omission of emissions and removals from land-use changes in the reporting.

B. Areas for further improvement

1. Planned or ongoing work by the Party

183. Planned or on-going improvements for the LUCF section include inventorying preserved forest areas and assessing their C stock, completing and evaluating soil sampling and the derivation of C stock changes in forest soils. More detailed work is also planned on the derivation of the stemwood to total tree biomass expansion factor.

2. Issues identified by the ERT

184. The ERT noted that C emissions and removals from forest conversion and the abandonment of managed lands are not reported. It was indicated to the ERT that Sweden had compiled the information on LUCF for its August 2000 submission to the Subsidiary Body for

Scientific and Technological Advice (SBSTA). It was also pointed out that the area of abandoned agricultural land is approximately equivalent to the area of forest converted to other uses, however the C dynamics are such that emissions and removals may not cancel each other out. While carbon sequestration in abandoned agricultural land reverting to forest may already have been captured in the forest inventory, it is nevertheless suggested that the NIR should provide basic information on areas undergoing land-use changes and the corresponding estimates of C removals and emissions, along with the rationale for not including these estimates in the corresponding CRF tables.

185. The ERT would also suggest improving the transparency of the NIR (see section on transparency above).

VI. WASTE

A. Sector overview

186. Emissions from the waste sector represented around 3% of total GHG emissions in 1999. Methane emissions, the major GHG from this sector, have decreased by almost 19% from 1990 to 1999, owing to the implementation of waste treatment policies. The waste sector has one key source according to a level assessment: methane emissions from solid waste disposal sites (SWDS), representing 3% of the Swedish inventory total.

187. Additional information provided by the Swedish team to the ERT allowed the ERT to track the information from data collection into emission estimates.

188. The Swedish waste generation and management system is partially known, as indicated during the review. The ERT was informed that there are around 270 municipal landfill sites, 70 of which are equipped with gas extraction. About half the total waste goes to the 25 largest sites in the country.

189. It was made clear during the review that four types of waste management practice are used in Sweden: landfilling, recycling, incineration and rottening. More data on waste flow variation and error reduction is recommended. The management practices applied to wastes should be quantified to facilitate the analysis. It is also good practice to provide a list of treatment facilities.

1. Institutional arrangements

190. The ERT was informed that Sweden implemented different policies in order to reduce the amount of waste getting into landfills. Different state agencies, such as the Swedish EPA, the Ministry of the Environment and regional and local agencies, work on the implementation of those policies. The reduction is evident in the inventory trend.

191. Statistics Sweden is responsible for building, updating and analysing the waste database for GHG inventory purposes. It reviews specific studies on different variables (waste composition, oxidation factors, etc.). These one-time studies are referenced in the NIR.

2. Verification

192. The Swedish Waste Management Association and Statistics Sweden provided estimates of emissions from SWDS. There are no verification procedures in place for this sector.

3. Completeness

193. All CRF tables were completed from 1990 to 1999 with minor omissions and/or inconsistencies, which are specified further. Estimates were reported for methane emissions from SWDS (Category 6A). CH_4 emissions from wastewater handling were reported as NE because this is considered to be a negligible activity since all wastewater is treated in aerobic conditions.

194. N_2O emissions from human sewage were not reported. Emissions from the incineration of waste have been estimated in the energy sector. They were entered correctly as noted elsewhere.

4. Transparency

195. The methodologies and assumptions for estimating emissions are summarized in the NIR and the detailed reports referenced there. Clarifications may be needed since country-specific data are based on different studies, referenced in the NIR in Swedish. Background tables were not completed in the CRF for the categories considered not important.

5. Uncertainties

196. Thorough uncertainty assessments were not performed in this sector. The ERT was informed that this is planned for future submissions. The preliminary assessment by the Swedish team indicate a probable high overestimation due to the uncertainty surrounding the fraction of degradable organic carbon dissimilated (DOC_f). The method used is that recommended by the IPCC Guidelines.

6. Recalculations

197. CH_4 emissions from SWDS were recalculated in the 2001 submission. Emissions for the entire sector were recalculated in the 2000 submission following the tier change arising from implementation of IPCC good practice guidance. The 2001 NIR mentions that recalculations have occurred, but without further explanations.

7. Consistency with the UNFCCC reporting guidelines and the IPCC Guidelines

198. The estimation of the key source in this category, methane emissions from SWDS, was consistent with the default methodology in the IPCC Guidelines and largely consistent with the tier 2 methodology in IPCC good practice guidance. The reporting of emissions from this source in the CRF and in the NIR was consistent with UNFCCC reporting guidelines. Some minor issues and suggested improvements are noted below.

B. Key sources

1. CH_4 emissions from SWDS

199. Emissions decreased by 18.8% between 1990 and 1999 due to recovery of landfill gas and other waste management policies developed and implemented at various levels: regional associations, local and national regulations.

Methodology, activity data and emission factors

200. Sweden used the IPCC default tier 2 methodology with country-specific assumptions to estimate CH_4 emissions from SWDS. The NIR provided a summary of the methodology and assumptions, which were described in detail to the ERT during the review.

201. The methodology diverged from the IPCC Guidelines in four areas: (i) the first order decay model time factor has shifted by six months; (ii) the half life of waste is assumed to be 7.5 years instead of 14.5 (IPCC default); (iii) the DOC_f is reduced from 0.77 (IPCC default) to 0.7; and (iv) the CH_4 oxidation factor is increased from 0 to 0.1. All these modifications are consistent with IPCC good practice guidance.

202. Data on municipal solid waste generation, waste composition and the percentage of MSW disposed of in SWDS were obtained by Statistics Sweden from the Swedish Association of Waste Management after 1994; from their own surveys and the Swedish Association of Waste Management for the period 1985 to 1993; and from the Swedish EPA in 1980.

203. Data on industrial waste, described in the NIR, cover the main industries: pulp, paper and cardboard, slaughterhouses and potato and vegetables processing plants. The first two, along with the tinned food industry, represented the majority of organic industrial waste in the early 1990s.

204. Dissimilated organic carbon (DOC) in the Swedish waste entering SWDS was calculated on the basis of waste composition estimates from surveys, not including the proportion of wood in the construction and demolition stream. CH_4 emissions were calculated as total methane generated minus methane oxidized and methane recovered.

Results from previous reviews

205. The S&A reports for 2000 and 2001 identified the absence of some values in the application of the tier 1 method. It is recommended that they be provided for comparison purposes.

C. Non-key sources

206. Wastewater treatment and waste incineration were reviewed at a summary level since no calculations are provided where amounts are negligible or where the category has been included elsewhere.

207. A key assumption is that there is no leakage of methane from anaerobic wastewater treatment plants. This assumption is based on expert judgement but is not supported by data from measurement.

208. Nitrous oxide emissions from industrial and domestic wastewater treatment have not been estimated in the NIR or CRF, being considered negligible. The actual production is documented in a report written in Swedish.

209. Waste incineration has been considered under the energy sector, with fuel combustion by the energy and manufacturing industries, and is entered as IE in the CRF.

D. Areas for improvement

1. Identified by the Party

210. The ERT was informed that Sweden planned to conduct more field studies in the future. The studies will focus on the following areas: DOC of garden waste, DOC of sludge from the pulp industry, fractions of household waste, organic content in demolition waste and the dissimilation of DOC.

211. The above mentioned studies will verify the DOC_F parameter value that is considered as too high. These findings may be useful for other Parties and might contribute to the IPCC good practice guidance.

212. Sweden provided information about its plans to implement a QA procedure for further inventories.

2. Identified by the ERT

213. Perform uncertainty estimates in accordance with IPCC good practice guidance default uncertainties.

214. Improve the waste management data generation and management. This will lead to improvement of emission coefficients and the assessment of the impacts of different policy in waste management.

215. Provide explanations for the recalculations of the 1990–1998 waste emissions in the 2000 CRF.

216. Provide a list of waste management facilities in the NIR, as required by the IPCC good practice guidance.

217. Estimate nitrous oxide emissions from wastewater for inclusion in future inventories.

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