YMPÄRISTÖMINISTERIÖ
MILJÖMINISTERIET
MINISTRY OF THE ENVIRONMENT

GREENHOUSE GAS EMISSIONS IN FINLAND 1990–2002

NATIONAL INVENTORY REPORT

to the UNFCCC Secretariat

Common Reporting Formats (CRF)
1990–2002

15th March 2004

PREFACE

Finland's National Inventory Report under the UNFCCC (United Nations Framework Convention on Climate Change) contains the following three parts:

Part 1 Description of the greenhouse gas emission inventory according to the UNFCCC new reporting guidelines (FCCC/SBSTA/2002/L.5/Add.1) containing description of the organisation of the national greenhouse gas inventory, IPCC and other methods applied in calculation of the year 2002 emissions and exceptions to the previous inventories. A summarising table (Table 1) of the emissions data for the years 1990–2002 is included as well as a description of the current emission trends.

Part 2 CRF (Common Reporting Format) data tables of Finland's updated greenhouse gas emission inventories for the years 1990–2002.

Part 3 Report on the methodology for calculating the greenhouse gas emission inventories has been sent to the UNFCCC Secretariat in the previous years. The report can also be downloaded from the website http://stat.fi/tk/yr/khkaasut_raportit_en.html. The website will be updated with the latest information by 1st April 2004.

Methodological improvements in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, and according to the recommendations by the Expert Review Teams, have been implemented in the present inventory as far as possible and will be implemented in their entirety as soon as possible.

In matters related to the content of the National Inventory Report and the CRF-datatables Ministry of the Environment would like to recommend to contact directly to Statistics Finland, Ms. Mirja Kosonen, PO Box 6 A FIN-00022 Statistics Finland, (mirja.kosonen@stat.fi), tel. +358- 9 -1734 3543, fax +358-9-1734 3429.

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CONTENTS (PART I)

PART I EMISSION INVENTORIES

EXECUTIVE SUMMARY

ES.1 Background information on greenhouse gas inventories and climate change

Finland has carried out greenhouse gas inventories since the 1990's to meet the obligations of the United Nations Framework Convention on Climate Change (UNFCCC). Inventory reports are delivered to the UNFCCC Secretariat and the European Commission annually.

A special task force, the Greenhouse Gas Working Group, was established 15th October 1998 by the Ministry of the Environment to act as an advisory body in the collection of greenhouse gas inventories and reporting of greenhouse gas emissions and reduction measures to the UNFCCC Secretariat and the European Commission.

The Working Group consisted of representatives from ministries, agencies and research institutes, including: Ministry of the Environment, Ministry of Trade and Industry, Ministry of Transport and Communications, Ministry of Agriculture and Forestry, Finnish Meteorological Institute, MTT Agrifood Research Finland, Finnish Forest Research Institute, Finnish Environment Institute, Statistics Finland, and VTT Technical Research Centre of Finland.

Later the need to organise the inventory as permanent activity has became obvious. So the Government made 30.1.2003 the decision in-principle, that Statistics Finland will assume the responsibilities of the Single National Entity in the national greenhouse gas inventory system. Statistics Finland will develop the necessary general and special inventory functions by the end of 2004. The national system will consist of the earlier network of agencies.

The Government's decision in-principle specifies the responsibilities in the preparation of the national climate strategy, as well as in the preparation of greenhouse gas inventory and in the international reporting. The permanent national system still needs additional mutual agreements between partners, that is Statistics Finland, agencies and ministries.

IPCC Good Practice Guidelines and Revised 1996 Guidelines or national estimation methods are used in producing greenhouse gas emissions inventories. The Common Reporting Format (CRF) tables are used in reporting the emission figures. Emissions projections are usually presented by source and by gas, and as total emissions in CO_2 equivalents. The responsibility of producing the emissions data is by several organisations, is presented in Section 1.2.

The national inventory and reporting system is being constantly developed and improved.

ES.2 Summary of national emissions and removals related to trends

Summary of the Finnish national emissions and removals for 1990-2002 is presented in Table 1.

TABLE 1. Summary of Finland's greenhouse gas emissions data for 1990–2002.
(Remark: Due to rounding the sum of subtotals does not equal to total figures.)

(Tg CO_2 equivalents)	**1990** (Base year)	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
CO_2													
fuel combustion	53.9	53.1	51.3	52.0	58.3	55.9	61.2	59.8	57.4	56.8	54.9	60.5	62.2
fugitive emissions from fuels (peat, oil and natural gas)	3.5	3.5	3.5	3.6	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
industrial processes	1.2	1.0	0.9	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.1	1.0	1.0
agricultural soils	3.2	2.8	2.3	2.2	2.1	1.7	1.8	2.1	2.0	2.0	2.0	1.9	2.1
other	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.7	0.8	0.7	0.7	0.7
CH_4	6.3	6.3	6.2	6.2	6.1	6.1	6.1	6.0	5.8	5.7	5.4	5.4	5.1
N_2O	7.9	7.4	6.9	7.0	7.1	7.4	7.4	7.6	7.5	7.3	6.8	6.8	6.8
SF_6, HFCs, PFCs	0.09	0.07	0.04	0.03	0.04	0.10	0.15	0.24	0.30	0.40	0.58	0.73	0,53
TOTAL	**76.8**	**74.8**	**71.8**	**72.4**	**78.8**	**76.3**	**81.7**	**80.7**	**78.1**	**77.5**	**75.0**	**80.6**	**82.0**
Land-use change and forestry (removals)	-23.8	-38.2	-31.9	-29.1	-17.3	-14.7	-21.0	-12.6	-9.7	-10.8	-12.0	-16.9	-18.0

ES.3 Overview of source and sink category emission estimates and trends

The main sources of greenhouse gas emissions have been divided according to the CRF tables into the following sectors: energy, industrial processes, agriculture, waste, and solvent and product use (Figure 1). The land use change and forestry sector (LUCF) acts both as a source and a sink for carbon dioxide emissions, currently absorbing approximately 20% of the annual emissions from other sectors as the CO_2 removals in this category exceed its emissions.

The energy sector is the most significant source of greenhouse gas emissions with over 80% share of the total emissions, which reflects the high energy intensity of the Finnish industry, extensive consumption for long space heating period, as well as energy consumption for transport in wide and sparsely inhabited country. The energy sector releases three greenhouse gases, CO_2, and small amount CH_4 and N_2O. Energy related CO_2 emissions vary mainly according to the economic trend, the energy supply structure, and climate conditions. Due to these reasons there was a 8.8 (+15 %) Tg CO_2 increase in the energy sector between the years 1990 and 2002. Total greenhouse gas emissions in 2002 amounted to 82 Tg CO_2 equivalents., which is 5,2 Tg (6.7 %) over the 1990 emission level.

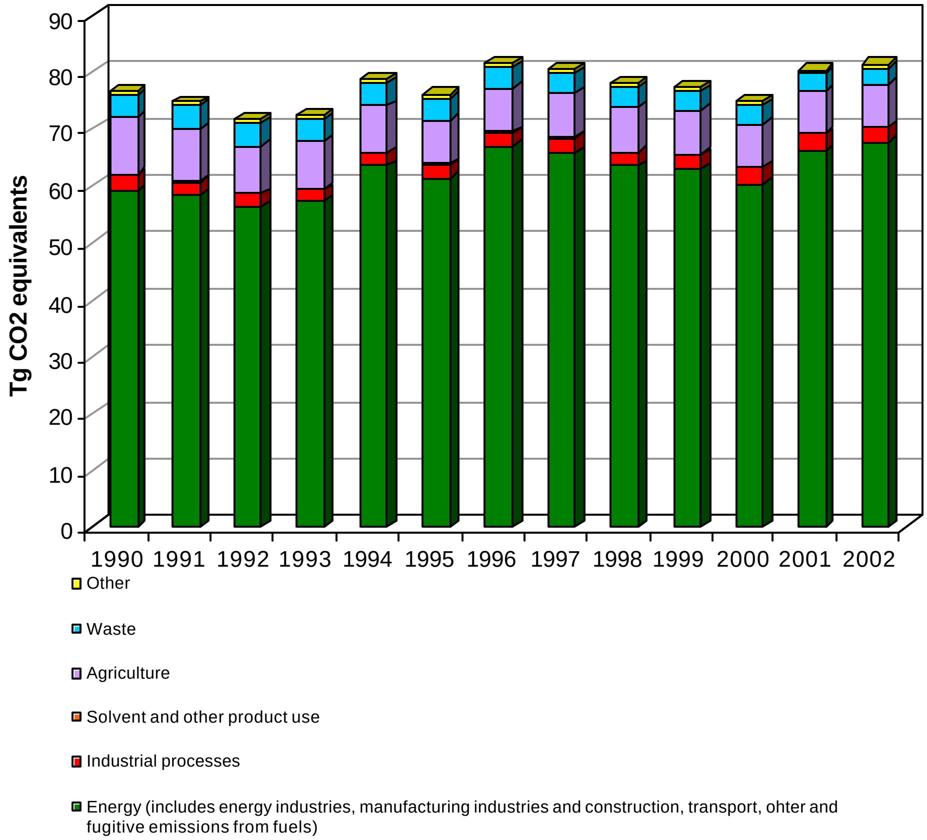

FIGURE 1. Finnish greenhouse gas emissions by source 1990–2002.

Agriculture is the second most significant source of greenhouse gas emissions, with approximately 9% of Finland's total emissions. Emissions from agriculture include CO_2, CH_4 and N_2O. The total emissions from agriculture have a clearly decreasing trend. The annual emissions have reduced approximately by 25% since 1990 due to decreases in cultivation of organogenic land, in the number of livestock, and in nitrogen fertilisation.

The industrial processes category accounts for approximately 4% of the total greenhouse gas emissions, and includes non-energy related releases of CO_2, CH_4, N_2O and F-gases. Emissions from industrial processes decreased significantly until 1993, but have since had a rapidly increasing trend. In 2002, the emissions were approximately equal to the 1990 level.

Also, the waste sector accounts for approximately 4% of Finland's total greenhouse gas emissions. The emissions consist of CH_4 and N_2O, and have had a decreasing trend in the 1990's. Overall, the annual emissions have decreased by over 25%.

Solvent and product use cause mainly N_2O emissions. Emissions from this sector are only 0.1% of Finland's total greenhouse gas emissions and have remained the same throughout the 1990's.

ES.4 Other information

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1 INTRODUCTION

1.1 Background information on greenhouse gas inventories and climate change

Climate change means anthropogenic alterations in the global climate, such as temperature increase, sea level rise, and severe and abrupt weather conditions caused by significant increases in greenhouse gas emissions. The latest report by the Intergovernmental Panel on Climate Change (IPCC) indicates that global temperatures could rise by 1.4–5.8 degrees by 2100. This means increases in average temperatures, which can have a significant impact on the local climates, weather conditions, and flora and fauna in areas around the world. The severity of the impacts will vary regionally and be difficult to predict in advance.

In Finland, climate change research in recent years was conducted among others by CLIMTECH climate change and technology programme (1999-2002), that investigated the development needs and possibilities of the technologies, which can be applied to control greenhouse gas emissions and climate change, and by FIGARE, the Finnish Global Change Research Programme (1999-2002). FINSKEN was a FIGARE project, co-ordinated by the Finnish Environment Institute, that developed consistent global change scenarios for Finland, including for example climate change and sea-level scenarios. The climate scenarios anticipate both annual temperature increase (1.8–5.2ºC) and rainfall increase (4–28%) by 2050 compared to the mean values of 1961–1990. These trends are expected to continue in the second half of the century. According to the present information, climate change is anticipated to have both direct and indirect impacts in Finland. The impacts are related for example to the endurance of the Northern ecosystems, winter tourism, increased flooding and the prevalence of pests and diseases as well as the possible growth of agriculture and forestry and decreased need for heating energy.

According to the United Nations Framework Convention on Climate Change (UNFCCC), ratified in 1994, and the Kyoto Protocol 1997, Finland is committed to reduce its greenhouse gas emissions to the 1990 level by 2008–2012 and submit an annual inventory reports of its anthropogenic greenhouse gas emissions to the UNFCCC Secretariat. Finland has carried out greenhouse gas inventories since the early 1990's, delivering inventory reports both to the UNFCCC Secretariat and the European Commission annually.

A special task force, the Greenhouse Gas Working Group (chaired by Mr Jaakko Ojala, counsellor, Ministry of the Environment, jaakko.ojala@environment.fi), was established 15th October 1998 by the Ministry of the Environment to act as an advisory body in collection of greenhouse gas inventories and reporting of greenhouse gas emissions and emissions reduction activities to the UNFCCC Secretariat and the European Commission.

The Working Group consisted of representatives from ministries, agencies and research institutes, including Ministry of the Environment, Ministry of Trade and Industry, Ministry of Transport and Communications, Ministry of Agriculture and Forestry, Finnish Meteorological Institute, MTT Agrifood Research Finland, Finnish Forest Research Institute, Finnish Environment Institute, Statistics Finland, and VTT Technical Research Centre of Finland.

Later the need to organise the inventory as permanent activity has became obvious. So the Government made 30.1.2003 the decision in-principle, that Statistics Finland will assume the responsibilities of the Single National Entity in the national greenhouse gas inventory system. Statistics Finland will develop the necessary general and special inventory functions by the end of 2004. The national system will consist of the earlier network of agencies.

The Government's decision in-principle specifies the responsibilities in the preparation of the national climate strategy, as well as in the preparation of greenhouse gas inventory and in the international reporting. The permanent national system still needs additional mutual agreements between partners, that is Statistics Finland, agencies and ministries.

IPCC Good Practice Guidelines and Revised 1996 Guidelines or national estimation methods are used in producing greenhouse gas emissions inventories. Common Reporting Format (CRF) tables are used in reporting the emission figures. Emissions projections are usually presented by source and by gas, and as total emissions in CO_2 equivalents to enable comparisons between the different greenhouse gases. Responsibility of producing the emissions data according to the CRF data tables is divided between several organisations, as presented in Section 1.2.

The national inventory and reporting system is constantly being developed and improved.

1.2 A description of the institutional arrangement for inventory preparation

According to the provisions of the COP/SBSTA/SBI decisions, Finland is carrying out the greenhouse reporting in consultation with the relevant ministries, institutes and experts. The Ministry of the Environment has the overall responsibility over the greenhouse gas inventory and reporting under the UNFCCC. Several different organisations produce information that is used as base or emissions information for the inventory. The Finnish Environment Institute and Statistics Finland have compiled the inventory. The National Inventory Report (Part 1) is compiled at the Finnish Environment Institute based on data from the above mentioned organisations.

Statistics Finland was appointed as the National Inventory Agency for the greenhouse gas inventory by a decision by the Government 30 January 2003. During the year 2004 the national system for greenhouse gas inventory will assume the permanent structure, which is confirmed by necessary agreements between Statistics Finland, agencies and relevant ministries.

Calculation of the Finnish 2002 greenhouse gas inventory data to be reported to the UNFCCC Secretariat was carried out by organisations presented in Table 2.

TABLE 2. Responsible institutes in calculation of the greenhouse gas emissions in Finland.

CRF category	Organisation responsible for the inventory
1.A	Statistics Finland VTT Technical Research Centre of Finland
1.B	Statistics Finland Ministry of the Environment Finnish Environment Institute (SYKE)
2 (I)	Statistics Finland Finnish Environment Institute (SYKE)
2 (II)	Finnish Environment Institute (SYKE)
3	Finnish Environment Institute (SYKE)
4	MTT Agrifood Research Finland
5	Finnish Forest Research Institute (Metla)
6	Finnish Environment Institute (SYKE)
7	Statistics Finland
International bunkers	Statistics Finland

1.3 Brief description of the process of inventory preparation

The inventory report is in practice compiled by the Finnish Environment Institute (SYKE) from material provided by the research institutes, agencies and ministries participating in the inter-ministerial working group set by the Ministry of the Environment. The CRF tables are compiled by the Finnish Environment Institute and Statistics Finland from data provided by the above mentioned organisations.

The greenhouse gas inventory was prepared by Statistics Finland, Finnish Environment Institute, VTT Technical Research Centre of Finland, MTT Agrifood Research Finland, Finnish Forest Research Institute (Metla) and Ministry of the Environment.

The following ministries, agencies and research institutes also participated in the work: Ministry of Trade and Industry, Ministry of Transport and Communications, Ministry of Agriculture and Forestry and Finnish Meteorological Institute.

1.4 Brief general description of methodologies and data sources

In this report, compilation of the year 2002 inventory is described more closely while compilation of the 1990–2001 inventories is presented at a general level. More detailed description of the methodologies is presented in the report "Greenhouse Gas Emissions and Removals in Finland" which is also available from the website: http://stat.fi/tk/yr/khkaasut_raportit_en.html. Documentation of the F-gases inventory is presented in Oinonen (2004).

Calculation methods for the years 1990–2002

There are differences in the calculation methods used for the years 1990–2001 emissions and year 2002 emissions. To facilitate a review of time series consistency, these differences are listed below. Changes in emission factors and activity data are not accounted.

CRF 1.A A new version of ILMARI calculation system is under development. The 2001 and 2002 inventories have been calculated using preliminary version of the new system. Calculation methods are the same as in the previous ILMARI, but the database is new. Also some classifications have been revised (for example NACE instead of the previous national industrial classification). This has caused some changes in the allocation between subsectors 1.A.1 and 1.A.2.

Previously reported indirect N_2O emissions caused by nitrogen deposit ion due to NO_x emissions in the energy sector were included in the emission estimates for the relevant sectors. Now these emissions have been removed from to inventory to increase transparency and comparability with other countries' inventories. Recalculation was made as a response to the centralized review (FCCC/WEB/IRI(3)/2002/FIN).

1991 emissions are not calculated with ILMARI; they are based on top-down estimates.

International bunkers: Calculation is included in the ILMARI system; see comments on CRF 1.A.

CRF 1.B NMVOC estimates for 2001 and 2002 are updated according to the results from the Finnish NMVOC calculation model at the Finnish Environment Institute. The whole time series will be updated in the next submission.

CRF 2 (I) Most parts of the calculation are included in the ILMARI system; see comments on CRF 1.A.

NMVOC estimates for 2001 and 2002 are updated according to the results from the Finnish NMVOC calculation model at the Finnish Environment Institute. The whole time series will be updated in the next submission.

CRF 2 (II) None.

CRF 3 None.

CRF 4 None.

CRF 5 None.

CRF 6 None.

CRF 7 None.

Use of bottom-up data

A specific feature for the Finnish emission inventories is use of compliance data reported by the industrial installations. The installations report their annual emissions data to the environmental supervising authorities according to the monitoring obligations determined in the environmental permits. After checking and approving the data the supervising authorities record the data into the database (VAHTI) from where it is available for emission inventory purposes. Statistics Finland and the Finnish Environment Institute collect this data and, after normal statistical checking (e.g. check of magnitude and trend) as well as an inter-comparison between the two institutes, the data is taken into the emissions inventory data systems of both Statistics Finland and the Finnish Environment Institute. For F-gases no VAHTI data is currently available.

1.5 Brief description of key source categories

Key sources are the emission sources, which have a significant influence on the total inventory in terms of the absolute level of emissions (2002), trend of emissions (change between 1990 and 2002) or both. There are two alternative methods for identifying key sources: Tier 1 and Tier 2. In the Tier 1 method, the emission sources are sorted according to their contribution to emission level or trend. In the Tier 2 method also the relative uncertainties of source categories are taken into account. Key sources are the emission categories which represent together 90% of the inventory uncertainty.

In Finland, key sources are identified using the Tier 2 method. Key sources by level in 1990 and 2002, and by trend are presented in Tables 3, 4 and 5. The number of key sources identified in 1990 and 2002 was 16 and key sources identified according to trend assessment was 18. The number of key categories decreased when compared with the previous inventory. This is mainly due to the change in aggregation level: CO_2 from combustion is aggregated to fuel-specific level in this key source analysis, and therefore some of the key source categories are very large. Therefore the threshold of 90% is obtained with a smaller number of source categories than in the previous key source analysis. Key source category summaries are also presented in Tables E and F in Annex 3.

TABLE 3. Key sources in 1990 (Tier 2).

A	B	C	E	F
IPCC Source Category	Gas	Base Year Estimate (Gg CO_2-eq)	Level Assessment with uncertainty	Cumulative Total of Column E
1.B.1 Solid Fuels: Arable peatlands	CO_2	2500	0.17	0.17
4.D. Agricultural soils: indirect emissions	N_2O	764	0.14	0.31
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N_2O	3506	0.11	0.42
1.B.1 Solid Fuels: Peat production areas	CO_2	1000	0.11	0.52
2.B.2 Nitric Acid Production	N_2O	1594	0.08	0.61
6.A. Solid Waste Disposal on Land	CH_4	3679	0.08	0.69
1.A. Fuel Combustion: Liquid fuels	CO_2	27386	0.04	0.73
4.A. Enteric fermentation	CH_4	1868	0.03	0.76
1.A. Fuel Combustion: Solid fuels	CO_2	15746	0.03	0.78
4.B. Manure management	N_2O	554	0.02	0.81
1.A.4. Other Sectors: Biomass	CH_4	245	0.02	0.83
1.A. Fuel Combustion: Other fuels	CO_2	5674	0.02	0.85
7.Other - non-energy use of fuels	CO_2	640	0.02	0.86
6.B.2 Domestic and Commercial Waste-water: densely populated areas	N_2O	84	0.02	0.88
1.A.1 Energy Industries: Other fuels	N_2O	141	0.01	0.89
1.A.3.b. Road Transportation: Cars without Catalytic Converters	N_2O	67	<0.01	0.90

TABLE 4. Key sources in 2002 (Tier 2).

A	B	D	E	F
IPCC Source Category	Gas	Current Year Estimate (Gg CO_2-eq)	Level Assessment with uncertainty	Cumulative Total of Column E
1.B.1 Solid Fuels: Arable peatlands	CO_2	2500	0.18	0.18
1.B.1 Solid Fuels: Peat production areas	CO_2	1000	0.11	0.29
4.D. Agricultural soils: indirect emissions	N_2O	557	0.10	0.39
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N_2O	2720	0.08	0.47
1.A.3.b Road Transportation: Cars with Catalytic Converters	N_2O	380	0.08	0.55
2.B.2 Nitric Acid Production	N_2O	1311	0.07	0.62
6.A. Solid Waste Disposal on Land	CH_4	2684	0.06	0.68
1.A. Fuel Combustion: Liquid Fuels	CO_2	26747	0.04	0.72
1.A. Fuel Combustion: Other fuels	CO_2	9388	0.03	0.75
1.A. Fuel Combustion: Solid fuels	CO_2	17273	0.03	0.78
1.A.4. Other Sectors: Biomass	CH_4	311	0.02	0.81
4.A. Enteric fermentation	CH_4	1562	0.02	0.83
7.Other - non-energy use of fuels	CO_2	720	0.02	0.85
4.B. Manure management	N_2O	378	0.02	0.87
1.A.1 Energy Industries: Other Fuels	N_2O	207	0.02	0.89
6.B.2 Domestic and Commercial Waste-water: densely populated areas	N_2O	65	0.01	0.90

TABLE 5. Key source categories by trend (Tier 2).

A	B	C	D	E	F
IPCC Source Category	**Gas**	**Base Year Estimate**	**Current Year Estimate**	**Trend Assessment with uncertainty**	**Cumulative Total of Column E**
1.A.3.b Road Transportation: Cars with Catalytic Converters	N_2O	35	380	0.21	0.21
4.D. Agricultural soils: indirect emissions	N_2O	764	557	0.15	0.36
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N_2O	3506	2720	0.10	0.46
6.A. Solid Waste Disposal on Land	CH_4	3679	2684	0.09	0.55
2.B.2 Nitric Acid Production	N_2O	1594	1311	0.07	0.62
1.B.1 Solid Fuels: Arable peatlands	CO_2	2500	2500	0.04	0.66
1.A. Fuel Combustion: Other fuels	CO_2	5674	9388	0.03	0.70
4.B. Manure management	N_2O	554	378	0.03	0.73
1.B.1 Solid Fuels: Peat production areas	CO_2	1000	1000	0.03	0.75
1.A.3.b Road Transportation: Cars without Catalytic Converters	N_2O	67	20	0.02	0.78
4.A. Enteric fermentation	CH_4	1868	1562	0.02	0.80
1.A.1 Energy Industries: Biomass	N_2O	10	83	0.02	0.82
6.B.2 Domestic and Commercial Wastewater: densely populated areas	N_2O	84	65	0.02	0.83
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs, PFCs	0.01	385	0.02	0.85
1.A.3.a. Civil Aviation	N_2O	57	4	0.01	0.86
1.A. Fuel Combustion: Liquid Fuels	CO_2	27386	26747	0.01	0.88
1.A.1 Energy Industries: Other Fuels	N_2O	141	207	0.01	0.89
1.A.4. Other Sectors: Biomass	CH_4	245	311	0.01	0.90

Key sources are also identified using sensitivity analysis for the level assessment (2002). In this method, rank correlation coefficients are computed between all input parameters and total emissions in 2002 (with a simulation tool Crystal Ball). The advantage of this method is that the sources of uncertainties are identified at a disaggregated level, which is useful when planning inventory improvements. The results of this method are presented in Figure 2.

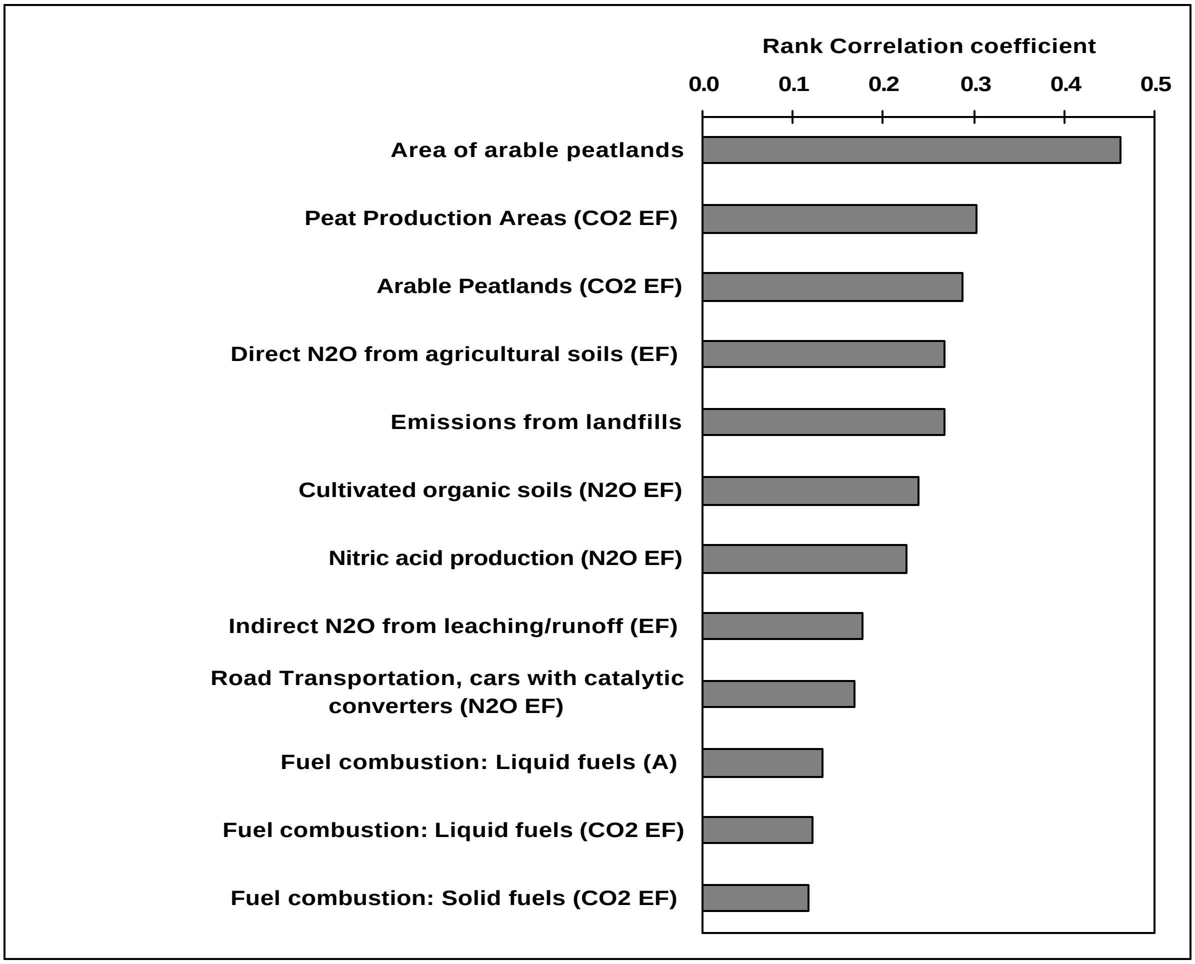

FIGURE 2. Key sources of the Finnish 2002 emission inventory identified using sensitivity analysis. In this method, rank correlation coefficients are calculated between calculation parameters and total emissions in 2002. In the figure, the parameters whose rank correlation coefficient is >0.1 are presented. EF denotes emission factor and A activity data

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues

Development of quality systems

Statistics Finland as the designated Single National Entity will coordinate the QA/QC activities of the national greenhouse gas inventory from this onwards.

The formal QA/QC plan was not prepared for the 2002 inventory, but it will be in use in the 2003 inventory as a part of the quality management system of the national greenhouse gas inventory. The quality management system under development will also include the QA/QC plans for the sectoral inventories of the expert institutes, documentation, archiving, review, verification end improvement procedures of the inventory. Statistics Fin-land will coordinate the project.

Archiving of the inventory

At the moment the annually reported CRF tables are archived both at the Finnish Environment Institute and Statistics Finland. [The method descriptions together with documents of the original data sources are archived at the Finnish Environment Institute].

Verification

The inventory project in Statistics Finland develops inventory review methods and verification procedures in the context of general QA/QC functions.

Confidentiality issues related to F-gases

The methodologies used to calculate potential and actual emissions of HFCs, PFCs and SF_6 are based on data obtained directly from corporate entities, universities and research institutions. These sources of data have responded to annual surveys providing information on, for instance, chemical quantities imported, exported and used in manufacturing products. The data gathering has been based on voluntary inquiries[1] and a promise not to disclose confidential information, or to report results in a manner that confidential information could be inferred.

Although there can be no absolute safeguards against breaches of confidentiality, care has been taken not to publish or otherwise release identified or identifiable data. To lessen the likelihood of such breaches, reporting has been based on anonymity. Moreover, to counteract the opportunities for others to infer confidential information, grouping of activity and emissions data have been carried out.

Because of the multidimensional structure of the tables in the CRF – emissions (and activity data in case of sectoral background data tables) are reported disaggregated to sub-source categories, to individual chemical species, to manufacturing, use and disposal emissions, to emissions calculated using different methods (Tier 1a, 1b, 2) – the grouping in many cases becomes an inadequate strategy to safeguard against breaches of confidentiality. The number of respondents is simply too small in certain categories to support such disaggregation.

For this reason it has not always been possible to report emissions on the most disaggregated level for a source category (paragraph 19 in UNFCCC Guidelines on Annual Inventories, FCCC/SBSTA/1999/6/Add. 1). In order to facilitate the assessment of completeness, the cells for which data cannot be reported due to confidentiality, have been marked with 'C' (paragraph 21.(e) of the Guidelines on Annual Inventories).

In the previous inventories, confidential data have been grouped over sub-source categories in order to include the emitted quantities, and to enable the data flow from sectoral report tables to summary tables. This does, however, inflict some damage to analysis possibilities, because components of emissions have been moved from one category to another. For instance, HFC-152a emissions from aerosols have been aggregated with HFC-152a emissions from refrigeration and air conditioning. With many such transfers from one category to another, the entire categorisation soon begins to lose its meaning. It is also a question of consistency if grouping over categories is carried out on an annual basis, and if the allocation of emissions to categories varies from one year to another. Moreover, also comparability becomes an issue: because a component of emissions from aerosols is confidential, emissions from aerosols in Finland cannot be compared to emissions from aerosols, say, in Denmark. Moreover, if one component of emissions from aerosols is added to emissions from refrigeration and air conditioning, this emission category also becomes non-comparable.

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[1] This means that the respondents submitting data to the Finnish Environment Institute have no obligation, based on law, to do so. In case of some of the companies, the voluntary basis of data gathering may change in future. The EU Commission has proposed a regulation that would set, among other things, an obligation *to report data to the Commission* (article 6, COM(2003) 492 final). Companies that would have to report include producers, importers and exporters, whose activity exceed a threshold of one ton per annum. As the proposal presently reads, the reporting might enable the Commission to draw material balances of F-gases for the European Community. This is a consequence of the fact that material flows suggested for monitoring would be imports into the community and exports from the community. At the moment of writing, the proposal is under discussion in the EU, and it is difficult to anticipate the amendments that might be made to the text. It seems at the moment, however, that the possible future reporting obligations might not be of use to individual EU member states as they try to fulfill their reporting obligations to the UNFCCC.

In order to minimise these damages to analysis possibilities, the grouping practice over categories has been given up. All confidential emissions data have been grouped and added to figures in the summary tables. Also, classification of one species-source category combination is kept constant over all inventory years. This means that a combination may be confidential in one year and not in the second year, but the combination for both years is classified confidential for the sake of consistency. These practices are hoped to inflict minimum damage to the usefulness of categorisation, consistency and comparability.

It should be noted that although every effort to protect the sources of data have been taken, the possibility of disclosing confidential information cannot be ruled out entirely. For example, it is possible to envisage a situation where the end-users of a certain chemical are numerous, but the importers of the chemical are few. In such a case, if only the end-users are surveyed, and not the entire chain of production, it is possible that the data is not confidential in case of the end-users, but it may be connected to the activity of just one or two importers.

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

A detailed uncertainty estimate using Tier 2 method (Monte Carlo simulation) was performed for the first time for the 2001 inventory. The uncertainties in input parameters were estimated using IPCC default uncertainties, expert elicitation, domestic and international literature and available measurement data (Monni & Syri, 2003). Since the previous inventory submission, only minor changes in uncertainty estimates have occurred (Monni, 2004). In 2002, the total uncertainty in the inventory was from -5 to +6% when expressed as the bounds of 95% confidence interval (in percent relative to the mean value). The trend uncertainty was ±5%-points. When the uncertainty estimate was performed using Tier 1 method, the corresponding uncertainties were ±7% and ±6%-points. When compared with the previous uncertainty estimate, these uncertainties have not changed.

The uncertainties by gas in 2002 are as follows: -4 to +6% for CO_2, ±25% for CH_4, -32 to +45% for N_2O and -7 to +18% for HFCs, PFCs and SF_6 together. Gas-specific uncertainties have changed slightly since 2001, mainly due to differences in uncertainty estimation. The uncertainties in f-gases are presented in Oinonen, (2004).

The results of uncertainty estimates according to Tier 1 and Tier 2 methods are presented in Tables A-D in Annex 3. The sums of total emissions in 1990 and 2002 differ from the sum in the inventory due to three reasons: firstly, CO_2 emissions from agricultural soils are not taken into account in the uncertainty estimation (this will be an area for further research). Secondly, the uncertainty estimates are based on figures sent to EC in December 2003. Thus some minor differences with the submission to UNFCCC might occur. Third, a minor reason is that rounding and simulation might alter the mean value slightly.

The current uncertainty estimate does not cover LULUCF.

1.8 General assessment of the completeness

Completeness by emission sources

The inventory is complete in coverage of emission sources with the following exceptions:

CRF 1 B 2 — Fugitive emissions from oil and natural gas: some emissions of CO_2, CH_4 and N_2O are estimated to be nearly zero (negligible). This has to be re-checked in the future inventories.

CRF 1 — International bunkers / lubricants: emissions of CO_2, CH_4 and N_2O are estimated to be nearly zero (negligible). This has to be re-checked in the future inventories

CRF 2.A, B, D — Emissions from industrial processes: CO_2 emissions from some source categories are estimated to be nearly zero (negligible). This has to be re-checked in the future inventories.

CRF 3. A,B,D — No compound specific data of NMVOC emissions available for conversion to CO_2.

CRF 4 — Rice cultivation and burning of savannas does not occur in Finland. Field burning of agricultural residues is occasional and small scale, thus these emissions are estimated negligible and not reported. Nitrogen fraction of certain vegetable and fruit crops will be estimated and included into the calculations in the future together with the improved evaluation of the areas of mineral and organic soils.

CRF 6 — Other (composting): emissions of CH_4 and N_2O are estimated to be nearly zero (negligible).

More detailed information on the non-covered emission sources is presented in the relevant CRF tables.

Completeness by geographical coverage

The inventory includes emissions from the autonomic territory of Aland (Ahvenanmaa). Information on the specified emissions for the territory of Aland estimated by the Finnish Environment Institute will be available at the website www.environment.fi > State of the environment > Air > Finland's greenhouse gas emissions by end of March 2004.

Completeness by timely coverage

In general, complete CRF tables are provided for all years. In the energy sector, recent studies on emission factors, more developed estimation models and updated energy data have caused some inconsistencies in the time series. These are described in more detail in Section 3.2. The time series will be recalculated in the future inventories to remove inconsistencies.

1.9 Remarks and abbreviations

The figures in the CRF tables are given at the calculation accuracy that the CRF programme uses (2 decimals). The actual emission estimates are not that accurate.

Abbreviations:

CS	country specific
CLRTAP	Convention of Long-Range Transboundary Air Pollution
D	IPCC default
DC	degradable components
H	high (high confidence in estimation), combined uncertainty (uc) of the activity data and emission factor, $uc < 10\%$
IE	included elsewhere
L	low (low confidence in estimation), $uc > 40\%$
M	medium (medium confidence in estimation), $10\% < uc < 40\%$
NE	not estimated
NEC	Net Emissions Ceiling Directive (2001/81/EC)
NO	not occurring
O	source estimated
PS	plant specific
UNECE	United Nations Economic Council of Europe

2 GREENHOUSE GAS EMISSION TRENDS

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

The aggregated greenhouse gas emissions include the six gases defined in the Kyoto Protocol, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and F-gases that include HFC and PFC combination groups and sulphur hexafluoride (SF_6). The emission levels are presented in tera grammes (Tg) of carbon dioxide equivalents, which is identical with millions of tonnes.

In 2002, Finland's total greenhouse gas emissions were approximately 82 Tg in CO_2 equivalents. This was approximately 5 Tg above the 1990 baseline level.

As illustrated in Figure 3, Finland's greenhouse gas emission volumes have varied considerably since 1990. This variation has mainly depended on what have been, at given times, the particular economic trends for the energy intensive sectors, the production level of hydropower, the level of imported electricity and the availability of alternative non-carbon energy sources. In Finland, the level of imported electricity is highly affected by the annual rainfall situation as the neighbouring states, Sweden and Norway, have significant hydropower capacities. The dry year 2002 gave Finland the opportunity to supply coal and peat fuelled power to the Nordic market, which production strongly raised CO_2-emissions.

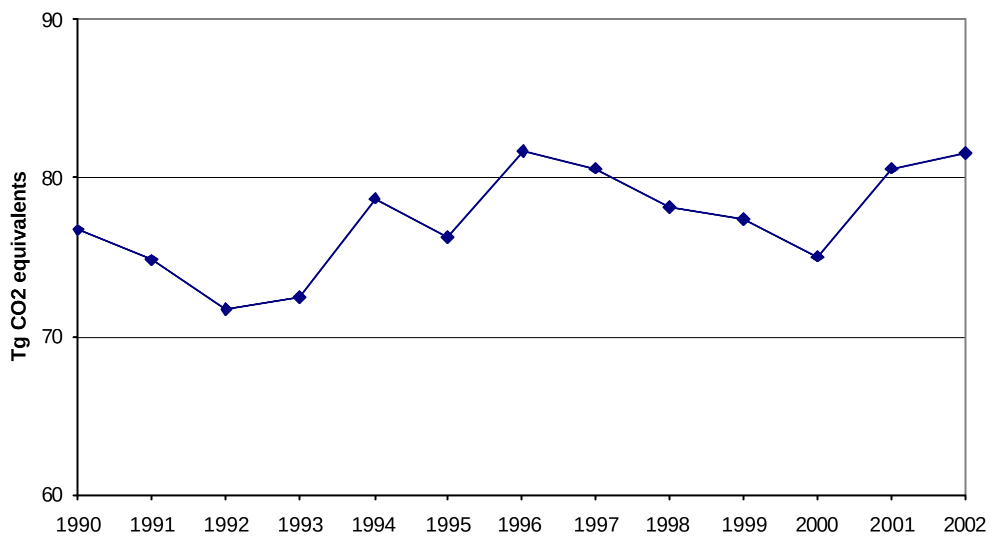

FIGURE 3. Finnish aggregated greenhouse gas emissions in 1990–2002.

The development of Finland's greenhouse gas emissions in the future has been modelled and projected by scenarios. According to the National Climate Strategy (2001), the greenhouse gas emissions are expected to increase to approximately 90 Tg carbon dioxide equivalents during the obligation period by 2010 and to 95 Tg by 2020, if additional climate policy measures are not carried out.

2.2 Description and interpretation of emission trends by gas

Carbon dioxide (CO_2) is the main greenhouse gas causing the climate change (Figure 4). In 2002, its share of Finland's total greenhouse gas emissions was as high as 85% and thus the CO_2 trends tend to be the same as the aggregated emission trends above. In 2002, the total CO_2 emissions were over 69 Tg, 11% above the 1990 baseline level. The largest source of carbon dioxide in Finland is fuel combustion in the energy industries, that is commercial power and heat production in power plants. Other sources of CO_2 are manufacturing industries, transport, and in minor scale industrial processes and agriculture.

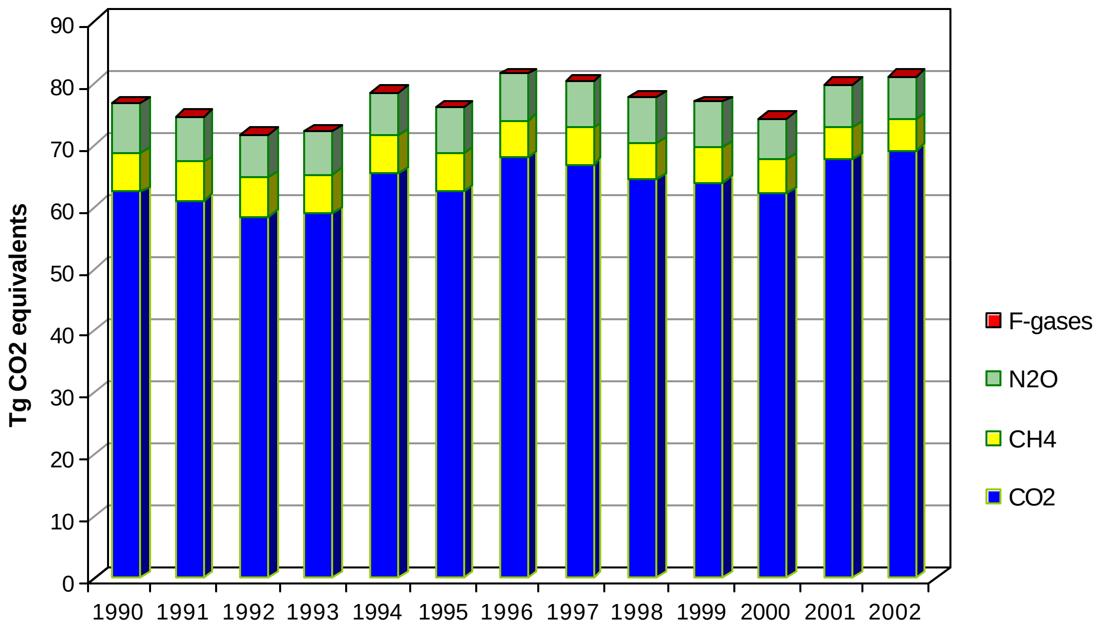

FIGURE 4. Finnish greenhouse gas emissions trend 1990–2002 by gas.

Nitrous oxide (N_2O) is the second most significant greenhouse gas in Finland with approximately 8% share of the total greenhouse gas emissions. In 2002, N_2O emissions were 6.8 Tg in CO_2 equivalents, reduced by 1.1 Tg from 1990. As illustrated in Figure 5 below, emissions have an oscillating trend. These emissions arise from agriculture, energy production, transport, industrial processes and waste, agriculture being clearly the largest source with over half of the total N_2O emissions.

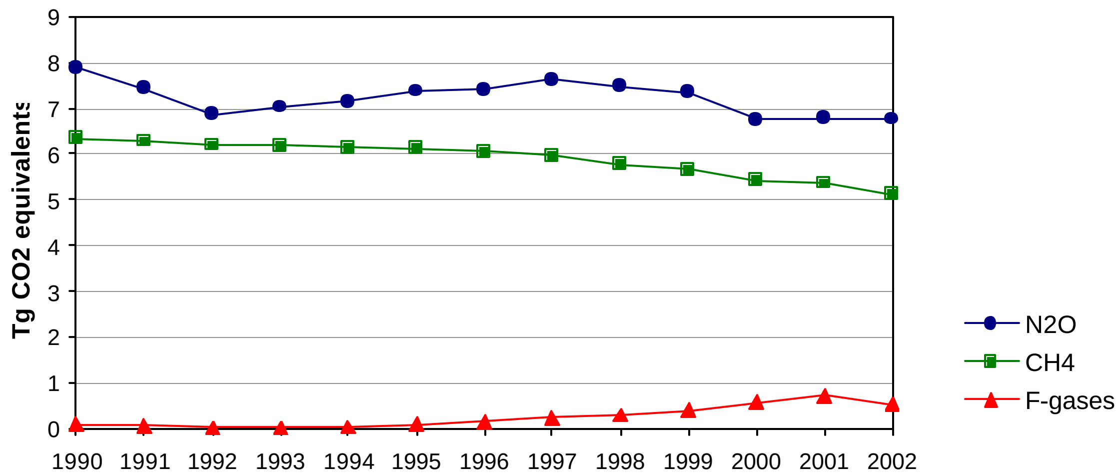

FIGURE 5. Finnish greenhouse gas emissions by gas excluding CO_2 in 1990–2002.

Methane (CH_4) emissions in Finland have been reduced significantly since 1990. Figure 5 illustrates a steadily decreasing trend. In 2002, CH_4 emissions were only 5.1 Tg in CO_2 equivalents, decreased by 1.2 Tg from 1990. CH_4 is still a significant greenhouse gas in Finland with 6% of the total net greenhouse gas emissions in 2002. The reduction between 1990 and 2002 is explained by changes that have occurred in the waste sector. The waste and agricultural sectors are the largest sources of methane emissions, with approximately 55% and 35% of the total methane emissions, respectively.

F-gases, that include HFC and PFC combination groups and sulphur hexafluoride (SF_6), are minor greenhouse gases but their emissions have strongly increased since 1990. The increase was more than five fold from 0.09 Tg CO_2 equivalents in 1990 to 0.53 Tg in 2002. This means that their share of the total greenhouse gas emissions has increased from 0.1% in 1990 to 0.7% in 2002. The rapid increase in the F-gas emissions began after 1995. F-gases, mainly HFC in Finland, are released from industrial processes.

2.3 Description and interpretation of emission trends by source

The main sources of greenhouse gas emissions are divided into the following sectors: energy, industrial processes, agriculture, waste, and solvent and product use (Figure 6).

The energy sector is clearly the largest source of greenhouse gas emissions with over 80% share of the total emissions. The energy sector releases three greenhouse gases: CO_2, mainly from fuel combustion in energy industries, CH_4 and N_2O. The emissions in the energy sector have varied considerably throughout the 1990's with an overall slightly increasing trend being visible.

In 2002, energy consumption in Finland totalled 33.5 million oil tonnes. Drought reduced the availability of hydropower to such an extent that the Nordic electricity markets approached a shortage of electricity. Electricity consumption in Finland totalled 83.9 TWh. Both the rising demand for export industry products and the steady increase in the consumption of electricity by households and services contributed to the growth. Carbon dioxide emissions from the use of fossil fuels rise to 62 Mt, an increase of 8,1 Mt (13%) on emissions in the year 1990. Coal and peat made up over two-fifths of the emissions.

By energy source, in 2002 the largest increase was in the use of coal, required for domestic electricity generation, and in the net imports of electricity. Imported energy accounted for 70 per cent of the entire energy supply. The use of wood-based fuels increased 6 per cent. However, the proportion of renewable energy sources, 23 per cent of the primary energy consumption, remained at the previous year's level owing to the scarcity of hydropower. Consumption of traffic fuels, particularly diesel fuel, increased slightly.

Agriculture is the second most significant source of greenhouse gas emissions, with approximately 9% share of the total emissions. In Finland, the emissions are released mainly from agricultural soils but also through enteric fermentation and manure management. Emissions from agriculture include CO_2, CH_4 and N_2O. The total emissions from agriculture have a clearly decreasing trend. The annual emissions have reduced approximately by 25% since 1990 due to decreases in cultivation of organogenic land, in the number of livestock, and in nitrogen fertilisation.

The industrial processes sector releases approximately 4% of the total greenhouse gas emissions, and includes non-energy related releases from mineral products (CO_2), chemical industry (CH_4 and N_2O), metal production (CH_4), and the consumption of halocarbons and SF_6. The most important industrial greenhouse gas emissions are the N_2O emissions from nitric acid production and CO_2 emissions from cement and lime production. The emissions from industrial processes decreased significantly until 1993, but have since had a rapidly increasing trend. The increase can be partly explained by the significant growth in the Finnish industry, mainly in the electronics but also in metal, forest and chemical industries. In 2002, the emissions of the industrial processes sector were approximately equal to the 1990 level.

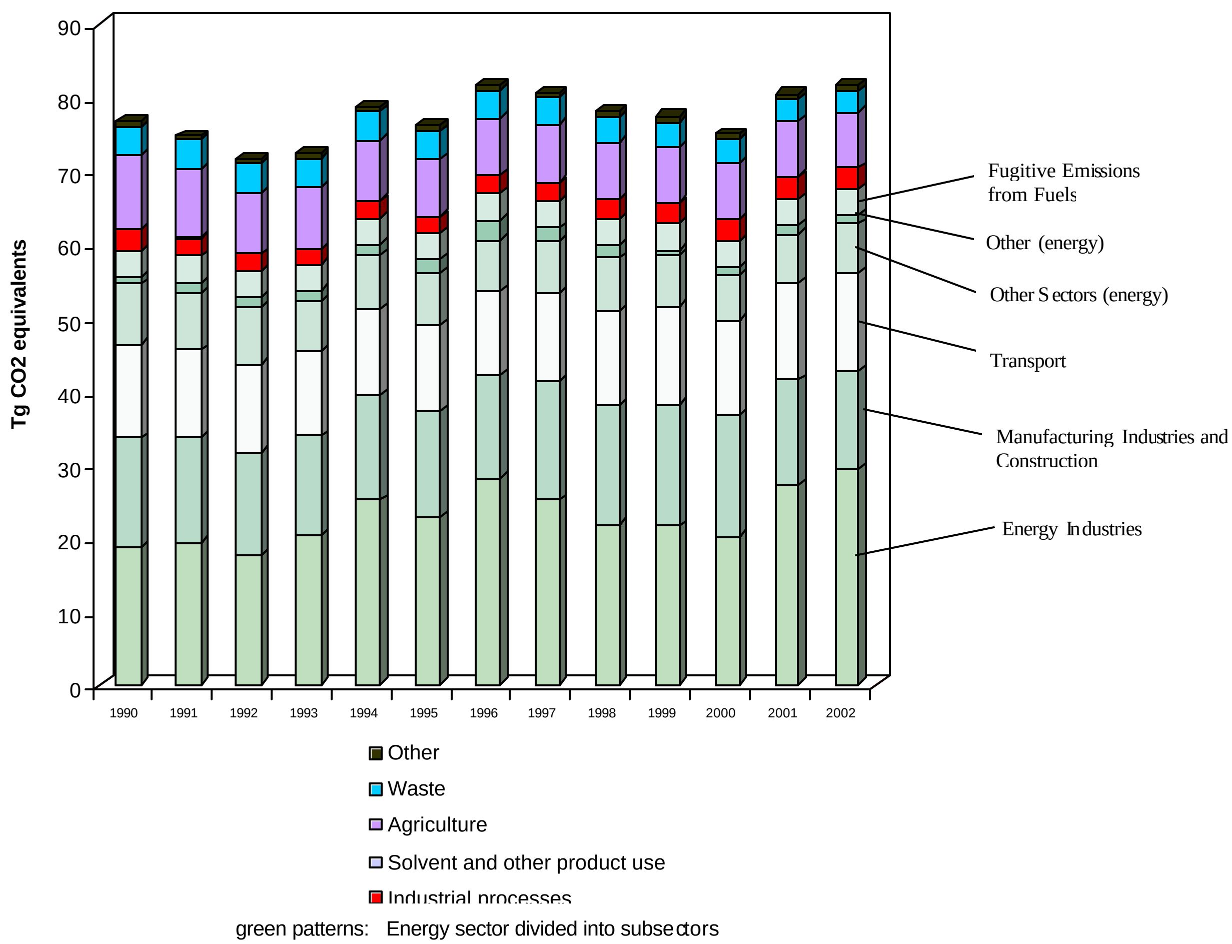

FIGURE 6. Finnish greenhouse gas emissions by source 1990–2002 excluding land-use change and forestry.

The waste sector accounts for approximately 4% of Finland's total greenhouse gas emissions. The emissions consist of CH_4 from solid waste disposal on land, and CH_4 and N_2O from waste water treatment. The emissions from waste had a decreasing trend in the 1990's. Overall the annual emissions have decreased by more than 25%.

Solvent and product use cause mainly nitrous oxide emissions and volatile organic compounds. N_2O is an actual greenhouse gas whereas the NMVOC compounds are indirect gases. Emissions from this sector are only 0.1% of Finland's total greenhouse emissions and have been slightly decreasing during 2001 and 2002.

2.4 Description and interpretation of emission trends of indirect greenhouse gases and sulphur oxides

Emissions of indirect greenhouse gases by gas

The emissions trends of the indirect greenhouse gases, sulphur dioxides, nitrous oxides, carbon monoxide and non-methane volatile organic compounds, are presented in Figure 7. The official emission data of SO_2, NO_x, NMVOCs and CO for 2002 has been reported to the UNECE CLRTAP Secretary by 12[th] February 2004 and posted on the website at URL www.environment.fi > State of the environment > Air, by end of March 2004. This website also provides other detailed information on the Finnish air pollutant emissions. The official emission data is also included in the inventory to be reported to the UNFCCC Secretary. The emission data for 1990-2002 in Figure 7 are final.

The **sulphur dioxide** emissions totalled 82,4 Gg out of which 80% originated in the energy sector, where energy industries generated 50% of the total emissions and manufacturing industries and construction 21%.

Nitrous oxides were generated exclusively in the energy sector. The total emissions were 208.2 Gg. Transport sector was responsible for 43% of the emissions. Energy industries as well as manufacturing industries and construction generated 23% and 22% of the emissions, respectively.

Carbon monoxide emissions, total 600.4 Gg, originated also exclusively in the energy sector, where transport generated 61% and other sectors (including small scale combustion in the residential energy sector as well as off road machinery in forestry, agriculture and fishery) 26% of the total emissions.

The **non-methane volatile organic compounds** totalled 151.1 Gg in 2002. 71% of the total emissions were generated in the energy sector, where transport generated 38%, other sectors (including small scale combustion in the residential energy sector as well as off road machinery in forestry, agriculture and fishery) 26% and fugitive emissions from fuels 5% of the total emissions. 20% of the NMVOC emissions originated from solvent and other product use and 8% from industrial processes.

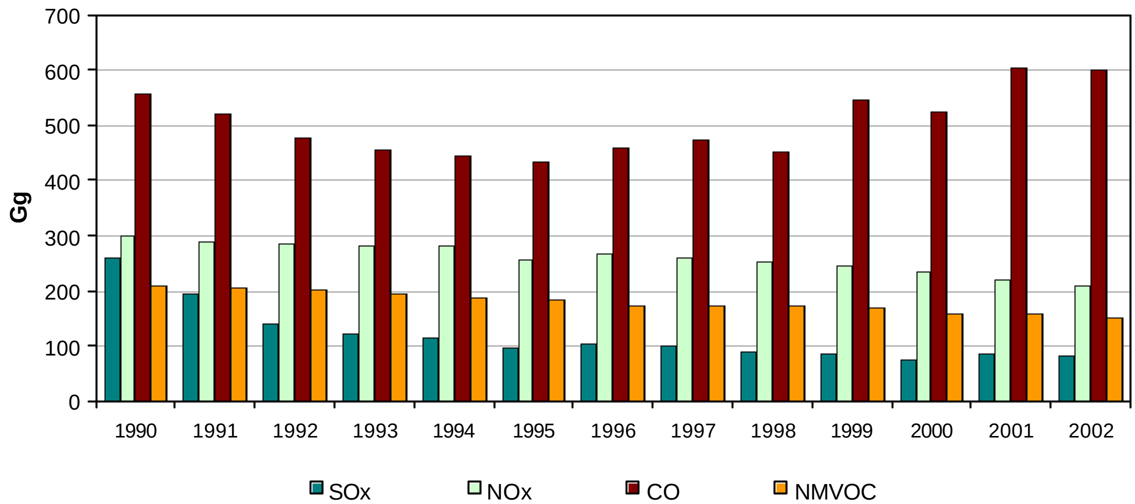

FIGURE 7. Finnish indirect greenhouse gas emissions trend 1990–2002 by gas

Emissions by source

The energy sector generated 80% (65.7 Gg) of the sulphur dioxide emissions, nearly 100% of both nitrous oxides emissions (205.1 Gg) and carbon monoxide emissions (594.9 Gg), and 71% (107.8 Gg) of the NMVOC emissions. Inside the energy sector transport generated 42% (86.2 Gg) of the nitrous oxides emissions, 62% (369.1 Gg) of the carbon monoxide emissions and 56% (60.3 Gg) of the NMVOC emissions.

Industrial processes generated 16% (13 Gg) of the sulphur dioxide emissions and 8% (11.4 Gg) of the NMVOC emissions.

Solvent and other product use generated 20% (29.7 Gg) of the NMVOC emissions.

The waste sector share was 1% (2.0 Gg) of the total NMVOC emissions.

3 ENERGY (CRF 1)

3.1 Overview of the sector

The energy sector is clearly the largest source of greenhouse gas emissions with over 80% share of the total emissions. Emissions from the energy sector 1990-2002 are presented in Figure 8.

In comparison between 2001 and previous years there is a difference in the allocation of emissions between CRF 1.A.1 and 1.A.2. Some power plants, which in the previous years had been allocated as autoproducers in the subsector CRF 1.A.2, have now been corrected to the CRF 1.A.1b. The effect of this is approximately 2.3 Gg of CO_2 in 2001 data (1.6 Gg in 2000).

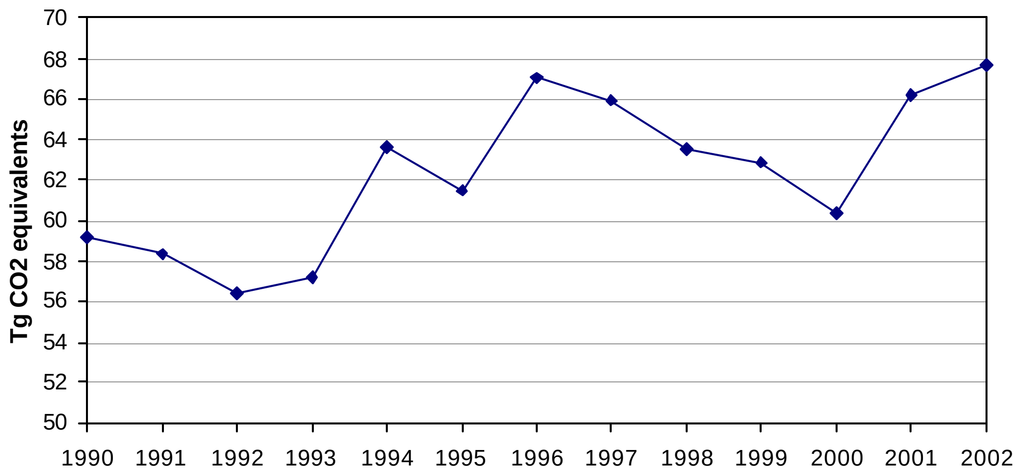

FIGURE 8. Finnish greenhouse gas emissions from the energy sector 1990–2002.

3.2 Fuel Combustion (CRF 1.A)

3.2.1 Source category description

All the existing point sources are included in the categories 1.A.1 Energy industries and 1.A.2 Manufacturing Industries and Construction, i.e. power plants and boilers (P_{fuel} > 5 MW) as well as industrial plants with a boiler. The total number of plants is approximately 1 000, including 2 000 boilers or industrial processes. These point sources cover together two thirds of the total annual fuel combustion.

Category 1.A.3 Transport covers emissions from road transport, civil aviation, railways, navigation and other transportation.

Categories 1.A.4 Other sectors and CRF 1.A.5 Other cover all the remaining fuel combustion activities that are not covered by the categories 1.A.1–1.A.3.

3.2.2 Methodological issues

All emissions from fuel combustion are calculated with Statistics Finland's ILMARI calculation system which follows mostly the Tier 2 method in the IPCC Guidelines. The ILMARI calculation system has been used for national emission calculations of CO_2, SO_2, NO_2, CO, CH_4, N_2O, NMVOC and PM emissions of fuel combustion from the year 1992. Also the year 1990 emissions have been calculated with ILMARI. The CRF tables for the year 1991 are produced by top-down estimates based on data for 1990 and 1992.

ILMARI combines three types of source data:

1. Detailed bottom-up data for point sources covers approximately 2/3 of the total annual fuel combustion (collected from the Regional Environment Centres' VAHTI data system, Electricity Statistics, District Heating Statistics and Manufacturing Industry Statistics). The total fuel consumption data as well as some aggregate sectoral or subsectoral fuel data are from the national Energy Statistics.
2. Aggregate transport and off-road vehicle data is originally calculated by the detailed calculation models LIPASTO and TYKO of the VTT Technical Research Centre of Finland and they cover approximately 1/6 of the total fuel combustion.
3. Aggregate sectoral (subsectoral) data for other sources (small combustion, residential and others) covers approximately the rest 1/6 of the total fuel combustion.

Categories 1.A.1 Energy industries and 1.A.2 Manufacturing Industries and Construction

A new version of the ILMARI calculation system is under development. The 2001and 2002 inventories have been calculated using a preliminary version of the new system. The calculation methods are the same as in the previous ILMARI, but a new database system has been constructed. Some parts of the system are still under development.

At the moment the data sources are the same as in the previous system, but other data sources with plant level data will be included into the system to reduce uncertainties in the sector.

The previous years will be recalculated in connection with the new system to remove inconsistencies in the sector. This will be done in sequence with the ongoing revision of the fuel consumption time series.

Some classifications have been revised (for example NACE instead of the previous national industrial classification). This has caused some changes in the allocation between the subsectors 1.A.1 and 1.A.2.

Calculation of the CO_2 emissions is based on a country specific (Tier 2, Revised 1996 Guidelines) method using detailed activity (fuel consumption) data and fuel specific emission factors. The emission factors are either IPCC defaults, country or plant specific (Annex 2). The inventory uses bottom-up data always when available. The country specific emission factors are listed.

The CO_2 emissions from coke and residual fuel oil used in the blast furnaces in iron and steel industry have been allocated to 1.A.2a Fuel consumption in Manufacturing Industry instead of 2.C Industrial Processes. There are two reasons for this: firstly, coke has usually been treated as energy producing material in the Finnish Energy Statistics. Secondly, the calculation of emissions is more accurate from the total coke consumption than from partly coke and partly blast furnace gases. The amount of CO_2 emissions from coke and residual fuel oil used in the blast furnaces is approximately 5 Gg (of 53–62 Gg CO_2 from the total fuel combustion). Other non-energy based emissions have been allocated to the relevant sub-categories of CRF 2 Industrial processes.

The SO_2 and NO_2 emissions are based on the emission data reported by the plants and recorded in the environmental authorities VAHTI database. The emissions are allocated to fuel based emissions (CRF 1) by each fuel and non-fuel-based (process) emissions (CRF 2).

The emissions of CH_4, N_2O and CO are based on a country specific method (Tier 2, Revised 1996 Guidelines) using detailed activity data and technology based emission factors for each boiler or process type (emission factors are available for approximately 250 categories of boilers and processes).

In the previous inventories the indirect N_2O emissions caused by nitrogen deposition due to NO_x emissions in the energy sector were included in the emission estimates for the relevant sectors. That was reported as an exception to the IPCC Guidelines. Now these emissions have been removed from inventory to increase transparency and comparability with other countries' inventories.

The activity data used in emission calculation is based on fuel consumption by boilers/processes and by fuel types. The basic data source is the VAHTI database which is complemented and cross-checked against other fuel data sources mentioned above.

Emission factors	The complete set of emission factors used in the inventory is presented in Annex 2.
CO_2	PS/CS/D
CH_4	PS/CS
N_2O	PS/CS
SO_x	Plant specific reported emission data (permitted installations' annual reports) or CS for fuel specific emission factors.
NO_2	Plant specific reported emission data (permitted installations' annual reports) or CS for fuel specific emission factors.
CO, NMVOC	CS

Category 1.A.3 Transport

The calculation method is in general consistent with the IPCC Guidelines.

CO_2 emissions within the transport sector and within the different transport modes are calculated using the LIPASTO calculation system (http://lipasto.vtt.fi/lipasto/index.htm) maintained and developed by the VTT Technical Research Centre of Finland. The LIISA sub-model of the LIPASTO calculates all emissions from the **road transport** for the years 1980–2022. The aggregate results of LIISA are taken into the ILMARI system. In the ILMARI calculation system road transport activity data covers diesel oil and motor gasoline consumption in road transport vehicles. Fuel consumption data is compared to the total diesel oil and motor gasoline consumption from the Energy Statistics (fuel sales). Road transport covers almost 100% of these fuels. Natural gas in road transport has been included since the 1999 inventory.

In the ILMARI system aggregate country specific emission factors for diesel oil and motor gasoline are used. The emissions are originally calculated by the very detailed VTT Technical Research Centre of Finland's LIPASTO model. In the LIPASTO calculation model the emission factors have been adjusted to the Finnish car population.

The activity data (fuel consumption) for **other transport sectors than road transport**, follows the data in the Energy Statistics. Part of the data is obtained directly from companies, another part is coming from national authorities, and the rest have been estimated with the LIPASTO and TYKO models.

There are differences in the **domestic aviation activity** data between the LIPASTO calculation model and the Energy statistics. The differences have to be checked to enable the results to be used in the ILMARI system. For emission factors used in civil aviation, railways, navigation, other transport, see the references mentioned in Boström (1994). Since the 1999 inventory the emission factors are mostly taken from the LIPASTO and TYKO models and completed with some IPCC 1996 default emission factors for CH_4 and N_2O.

The emissions from inland waterways passenger transport are not included in the domestic navigation model MEERI (a sub-model of LIPASTO). At the moment there is no data available for estimation of these emissions.

The estimated emissions from **off-road machinery** (machinery used in construction, agriculture and other applications) are included in the inventories and reported under the relevant emission sectors. The results of the VTT Technical Research Centre of Finland's new off-road machinery model (TYKO model) have been used in the ILMARI from 1999 onwards.

The ILMARI fuel consumption for off-road machinery is allocated according to the Energy statistics which leads to the following division in the CRFs: the emissions fall into CRF categories 1.A.3 Other Transportation, CRF 1.A.4c Agriculture/Forestry/Fisheries and CRF 1.A.2f Other/Construction

Categories 1.A.4 Other sectors and CRF 1.A.5 Other

The calculation method is consistent with the IPCC Guidelines. A closer description for the method is given in connection with categories CRF 1.A.1–1.A.2 (ILMARI).

Activity data is obtained from the energy statistics. For the applied emission factors, see CRF 1.A.1–1.A.2 for further information.

3.2.3 Uncertainty and time series' consistency

Due to new results from the transport and off road machinery calculation models and other updates of activity data and emission factors there are some inconsistencies in the time series of the energy sector subcategories. These will be recalculated in the following inventories. The recalculated time series will be included in the new version of ILMARI.

In the fuel combustion sector, the uncertainty in 2002 emissions is -2...+3%. Finland has no fossil fuel production – all fossil fuels are imported, and these statistics are very accurate. The allocation of total fuel use into sectoral shares is more uncertain. The most important factor affecting the uncertainty in fuel combustion is N2O emission factor for cars with catalytic converters.

Although the total fuel sales for most fuels are quite well known, there are difficulties in allocation of some fuels. The most difficult fuels to allocate are gasoil, which is used in space heating, off-road machinery, water transport etc., as well as residual fuel oil, which is used in steam/heat production, industrial processes and space heating. There are large uncertainties in the fuel consumption data within these sectors (1.A.4 and 1.A.5). The errors made in the allocation do not affect the total CO_2 emissions, but might cause relatively high errors in other emissions, because the emission factors vary a lot depending on the type of technology (for example NO_x emissions from space heating compared to NO_x emissions from diesel engines).

3.2.4 Source -specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Source-specific QA procedures and QC checks will be explicated in the QA/QC plan for the 2003 inventory.

At present, no verification has been carried out for the specific source-sector emissions.

3.2.5 Source -specific recalculations including changes made in response to the review process

Categories 1.A.1 Fuel Combustion

The indirect N_2O emissions due to atmospheric deposisition of NO_x emissions have been removed from the inventory in the fuel combustion sectors. (see 3.2.2)

3.2.6 Source -specific planned improvements

Categories 1.A.1 Energy industries and 1.A.2 Manufacturing industries and construction

Emissions for the year 1991 are not calculated with the same model. There are estimates of the total sectoral emissions in CRF Table 10, but these may be revised in the future. There has been progress in the harmonisation of emissions from domestic air and water transport between the ILMARI and LIPASTO calculation models. However, all results for the years 1990–2000 have not yet been updated to the CRF tables. This will be done as soon as possible. At the moment, there are some differences in the activity data, which need to be checked.

Some minor updates for the years 1992–1994 will be made in the future. There are some ongoing research activities for producing better data from residential, service sector and off-road machinery fuel consumption. The changes in the activity data should not affect the total CO_2 emissions but the sectoral breakdowns may change.

The CO_2 emission factor for **municipal solid waste** needs to be revised.

The **non -CO_2 emission factors** used in ILMARI are based on research data from the beginning of the 1990's and appropriate for emission calculations for that period. Since then, however, the combustion conditions and fuel mixes have changed, and an update of the emission factors based on research and measurements under current conditions is needed. This is especially needed for N_2O emissions from fluidised bed combustion due to its growing importance for the Finnish emissions inventory.

In addition to measurements, the IPCC default emission factors and international research carried out after 1990 on the CH_4 and N_2O emissions from combustion should be evaluated and used when updating the emission factors. The N_2O and CH_4 emissions are very much dependent on both the fuel type and combustion conditions. This should be taken into consideration when deciding if and how the new data should be applied.

Results from new measurements on CH_4 and N_2O emission factors of certain boiler types have been used in the year 2000 inventory. As expected, the results showed that the N_2O emission factors for fluidised bed combustion were overestimated. The time series will be updated in the future inventories.

The oxidation factor of **peat combustion** has been changed from 0.98 to 0.99 (IPCC default). However, this correction has not yet been made to years 1992–1994. There are also some other minor corrections for these years which will be made in the future.

Category 1.A.3 Transport: Civil aviation, railways, navigation and other transport

There are differences in the domestic aviation activity data between the LIPASTO calculation model and the Energy statistics. The differences have to be studied to enable use of the results to be used in the ILMARI system.

Categories 1.A.4 Other sectors and CRF 1.A.5 Other

More detailed data is needed on the allocation of gas oil and residual fuel oil to different sectors and types of use. Emission factors for small combustion of wood need to be studied further to achieve better annual comparability. Recalculation of time series for all non-point sources is underway. The results of the recalculation will be updated to the CRF tables as soon as possible.

The time series for the NMVOC emissions from residential fuel combustion is not constant due to changes in the activity data and emission factors. The time series will be updated in the future inventories. This applies also partly to CH_4, N_2O and CO emissions.

General

When preparing the CRF tables for 1990, some differences between total emissions of SO_2 and NO_2 were noticed compared to the previously published official time series. These differences will be checked in the future.

3.3 Fugitive Emissions from Fuels (CRF 1.B)

3.3.1 Source category description

CRF category 1.B.1 Fugitive emissions from solid fuels include in Finland the fugitive CO_2 and CH_4 emissions that arise particularly from peat production (preparation and profiling of peat soils and stockpiling of peat). The current inventory includes emissions from the production areas (surface emissions and emissions from stockpiles and ditches) and from arable peatland classified as reservoirs for future peat production. The areas and emission factors used in the inventory are uncertain and the calculated emissions have therefore been rounded to the nearest integer expressed in Tg CO_2. The same emission estimates have been used for all years in the inventory (1990–2002). Efforts to improve the estimates are underway. There are no coal mines in Finland.

CRF category 1.B.2 Fugitive emission from oil and natural gas include CO_2 emissions from venting and flaring from oil refineries (CRF 1.B.2c.i Venting). Only CO_2 emissions are reported, other emissions are estimated to be negligible. Methane emissions in CRF 1.B.2b.iii Other leakage include emissions from emptying of natural gas pipelines for extension work. Other leakages from the pipelines are estimated to be negligible as the pipelines are relatively new and only 5% of the natural gas is distributed via local networks to small consumers (households, restaurants, greenhouses etc.) The NMVOC emissions originate from oil refineries and storage of chemicals at the refineries, road traffic evaporative emissions from cars, petrol distribution chain and refuelling of cars. There is no exploration or production of oil and natural gas in Finland.

3.3.2 Methodological issues

Category 1.B.1 Fugitive emissions from solid fuels

The calculation method is in general consistent with the IPCC Guidelines. The calculation method for peat is country specific The peat production area in Finland is around 50 000-60 000 ha (e.g. Selin 1999) and the peatland classified as peat production reservoirs comprise approximately 100 000-150 000 ha (Laine *et al*. 1998). The annual CO_2 emissions from peat production sites are estimated as 1.0 Tg CO_2. In addition emissions from peat production reservoirs are estimated as 2.5 Tg CO_2.The CO_2 emission factor for peatland that are classified as peatland reservoirs is approximately 450 g CO_2 m^{-2} a^{-1}. Together these emissions total in 3.5 Tg. The calculation of fugitive emissions from the peat production areas and peat production reservoirs will be reassessed in the future according to the results from the on-going research programme "Greenhouse Impacts of the Use of Peat and Peatlands in Finland 2002-2005" and new guidance from IPCC (GPG LULUCF).

Category 1.B.2 Fugitive emission from oil and natural gas

The calculation method is consistent with the IPCC Guidelines. The CO_2 and CH_4 emission estimates are based on plant specific information. The NMVOC emissions from oil storages are based on emission data from the Regional Environmental Centres' VAHTI database. Evaporative emissions from cars is based on expert estimation at the VTT Technical Research Center of Finland and emissions from petrol distribution chain and refuelling of vehicles on expert estimation of Finnish Gas and Oil Federation and on expert estimations of companies not members of the federation.

3.3.3 Uncertainty and time series' consistency

The uncertainty in fugitive emissions from fuels is high, -59...+106%, dominated by the uncertainties in emissions related to production of peat fuel. The most important factors affecting the uncertainty are the area of arable peatlands, CO_2 emission factor for peat production areas and CO_2 emission factor for arable peatlands. The activity data on cultivated peatland classified as reservoirs for future peat production are uncertain and under review, as well as the allocation of the emissions (Energy, Agricultural or LUCF sector).

3.3.4 Source -specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Source-specific QA procedures and QC checks will be explicated in the QA/QC plan for the 2003 inventory.

At present, no verification has been carried out for the specific source-sector emissions.

3.3.5 Source -specific recalculations including changes made in response to the review process

No recalculations have been made to the previous inventories.

3.3.6 Source -specific planned improvements

Calculation of the emissions from 1.B.1 Fugitive emissions from solid fuels will be made for the whole period since 1990 when improved data on areas of peatland and the emission factors is available.

The results of the NMVOC calculation model of the Finnish Environment Institute have to be updated into the CRF tables 1.B.2 Fugitive emission from oil and natural gas to years 1990–1999. Calculation of the fugitive emissions from distribution of oil and natural gas (which were estimated to be negligible) will be carried out according to the IPCC default methodology in the following inventories.

3.4 Reference approach

Reference approach (RA) is done using import, export, production and stock change data from the energy balance (EB) sheet published in annual energy statistics. However, RA table requires liquid fuels reported in more disaggregated level than in the EB sheet. This data was taken from the background data of EB.

Another difference is that in the EB sheet stock changes and statistical differences are combined for certain fuels, whereas in the RA table only stock changes are reported.

In the 2002 inventory the difference of CO_2 emissions between RA and Sectoral Approach (SA) was +0,95%, which is acceptable.

Another reference calculation for 2002 inventory is included in Annex 1. In addition to the EB sheets there are CO_2 emissions calculated directly from the EB sheet. This calculation shows 0.1% difference compared to the SA calculation for year 2002.

3.5 International bunkers

3.5.1 Source category description

International bunkers cover international aviation and navigation according to the IPCC Guidelines.

3.5.2 Methodological issues

The emissions are calculated by the ILMARI calculation model of Statistics Finland (see closer CRF 1.A). Fuel consumption by transport mode is obtained from the energy statistics and it includes fuel sales to ships and planes going abroad. The country specific emission factors used are the same as for domestic transport.

The case of Aland could be seen as an exception to the IPCC definitions. In the present inventory all trips going to Sweden via Aland are treated as international, because the number of passengers (or cargo) leaving or entering the ships in Aland is very low. According to the IPCC methodology, the trip should be divided into domestic and international parts.

However, both the desk review report and the in-country review report of the Finnish greenhouse gas inventory accept the allocation used in the inventory to be consistent with the Revised 1996 IPCC Guidelines and the Good Practice Guidance.

3.5.3 Uncertainty and time series' consistency

No uncertainty estimation for international bunkers has been carried out.

3.5.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Source-specific QA procedures and QC checks will be explicated in the QA/QC plan for the 2003 inventory.

At present, no verification has been carried out for the specific source-sector emissions.

3.5.5 Source-specific recalculations including changes made in response to the review process

None.

3.5.6 Source-specific planned improvements

Harmonisation of emission factors in the ILMARI and LIPASTO calculation models is underway. The results will be updated to the CRF tables as soon as possible.

4 INDUSTRIAL PROCESSES (CRF 2)

4.1 Overview of the sector

Industrial greenhouse gas emissions contribute about 4% to the total anthropogenic greenhouse gas emissions in Finland. The most important industrial greenhouse gas emissions are the N_2O emissions from nitric acid production, and CO_2 emissions from cement and lime production. F-gases are together only about 0.6% of the total greenhouse gas emissions in Finland. Coke and ethylene production release small amounts of CH_4. The emissions from industrial processes have fluctuated somewhat during the 1990's. The most significant change is the increase of emissions of F-gases which are now more than five fold compared to the 1990 emissions. The N_2O emissions have decreased significantly almost equalling the increase of the F-gases. The CH_4 emissions have increased by nearly 37% but their contribution to the total industrial emissions is very small. Industrial CO_2 emissions decreased considerably at the beginning of 1990's, then increased during the latter part of the 1990's and are currently about 15% lower than emissions in 1990. The emission trend of greenhouse gas emissions in CO_2 equivalents from industrial processes is presented in Figure 9.

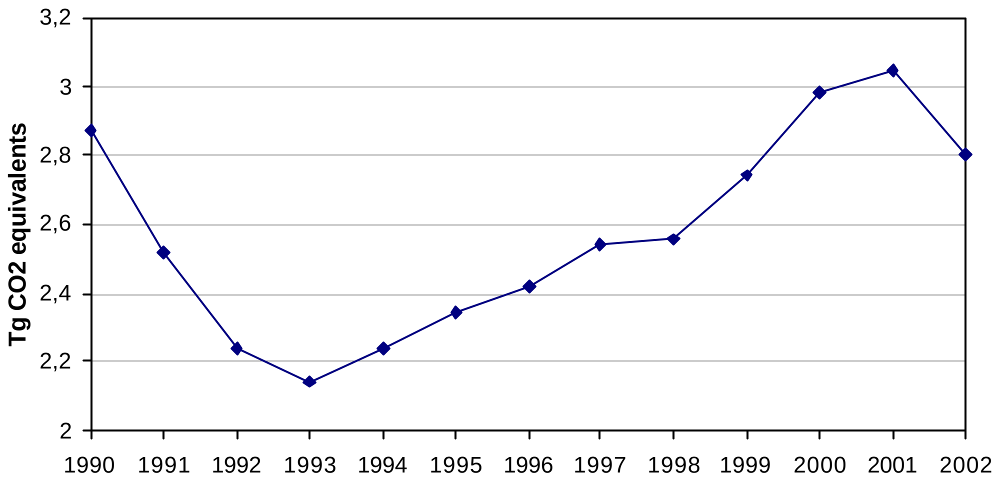

FIGURE 9. Finnish greenhouse gas emissions trend from the industrial processes sector 1990–2002.

4.2 Mineral Products (CRF 2.A)

4.2.1 Source category description

At the moment the most important non-energy CO_2 emission sources are cement and lime production. Lime production includes production in steel industry.

The NMVOC emissions from road paving are included. Asphalt roofing is included in road paving.

The SO_2 emissions are not split between fuel based and non-fuel based. All SO_2 emissions are reported under CRF 1.A.2f.

4.2.2 Methodological issues

CO_2 emissions from cement and lime production are calculated by Statistics Finland. The calculation method is consistent with the Revised IPCC 1996 Guidelines. Activity data for calculation of the CO_2 emissions from cement and lime production are obtained from the Manufacturing Industry Statistics as well as from the production plants directly. The emission factors are the IPCC default factors.

Due to lack of clinker production data, CO_2 emissions from cement production have been calculated from cement data using 60% lime content (data received from plant operators). Thus CO_2 emission factor is $44/12*0.6$ t/t $_{cement}$ = 0.471 t/t $_{cement}$. According to IPCC Good Practise Guidance, this methodology should be replaced with clinker-based method.

The **NMVOC emissions from road paving and asphalt roofing** are calculated at the Finnish Environment Institute. The activity data and emission factors are from Fortum Oil and Gas Ltd. (Blomberg 2002).

4.2.3 Uncertainty and time series' consistency

The uncertainty in emissions from cement production and lime production together is around ±6% in 2002. The total uncertainty in all industrial non-combustion emission together is -27...+47%.

4.2.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Source-specific QA procedures end QC checks will be explicated in the QA/QC plan for the 2003 inventory.

At present, no verification has been carried out for the specific source-sector emissions.

4.2.5 Source-specific recalculations including changes made in response to the review process

No recalculations have been made to the previous inventories.

4.2.6 Source-specific planned improvements

CO_2 emissions from the use of mineral products need to be estimated.

4.3 Chemical Industry (CRF 2.B)

4.3.1 Source category description

All ammonia currently used in Finland is imported from other countries. In 1990–1993 small amounts (4–30 kt per year) were produced using mainly peat and saw dust as raw material. The CO_2 emissions from these processes have not been estimated and included in the inventory.

Ethylene production is a source of CH_4 emissions. Ethylene production in Finland has fluctuated from about 180 to 260 Gg ethylene per year between 1990 and 2002.

Nitric acid production is a source of N_2O emissions. Nitric acid is produced at two sites (in 1990–1992 at three sites) in Finland. The production has varied from about 430 to 550 Gg nitric acid per year. Adipic acid is not produced in Finland.

The NMVOC emission sources include chemical industry and storage of chemicals at the sites.

4.3.2 Methodological issues

For **N_2O emissions** default calculation method based on measurements is used (activity data * emission factor). The emission factor is plant specific and based on measurements carried out at the factories in 1999. The method is consistent with the IPCC Guidelines. The activity data is obtained directly from production plants.

The **CH_4 emissions** have been calculated with the IPCC default emission factor 1 g CH_4/kg ethylene produced. The annual ethylene production figures have been obtained from the production plants and manufacturing statistics. The annual nitric acid production figures have been obtained from the production plants.

The **NMVOC emissions** are based on emission data from the Regional Environment Centres' VAHTI database and collected by the Finnish Environment Institute.

4.3.3 Uncertainty and time series' consistency

The uncertainty in nitric acid production is -57...+100% in 2002. The uncertainty is mainly due to variability of emissions according to process conditions. The uncertainty in ethylene production is around ±21%.

4.3.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Source-specific QA procedures and QC checks will be explicated in the QA/QC plan for the 2003 inventory.

At present, no verification has been carried out for the specific source-sector emissions.

4.3.5 Source-specific recalculations including changes made in response to the review process

No recalculations have been made to the previous inventories.

4.3.6 Source-specific planned improvements

Industrial emission sources for CH_4 and the suitability of the IPCC default emission factors should be studied further.

4.4 Metal Production (CRF 2.C)

4.4.1 Source category description

CH_4 emissions from coke production are included in the inventory.

The NMVOC emission sources include iron and steel production and secondary aluminium production. Degreasing and painting are included in CRF 3.B.

SF_6 emissions from magnesium die casting are included in the inventory.

4.4.2 Methodological issues

CH_4 emissions from coke production are calculated at Statistics Finland. Activity data for the calculation is obtained from the Energy Statistics. The emission factor 0.5 kg/t is the IPCC default value (IPCC 1996). The calculation method for CH_4 is consistent with the IPCC Guidelines. The CO_2 emissions from coke and residual fuel oil used in blast furnaces are allocated in metal production in the energy sector CRF 1.A.

In the earlier inventories also CH_4 emissions from pig iron and sinter production were reported. Based on the Revised 1996 IPCC Guidelines and measurements carried out at the Finnish plants, these emissions are now considered to be negligible and omitted from the inventory.

The NMVOC emissions from iron and steel production and secondary aluminium production are calculated at the Finnish Environment Institute based on emission data from the Regional Environment Centres' VAHTI database and the Technology Industries of Finland. The emission factors are taken from the Joint EMEP/Corinair Atmospheric Inventory Guidebook.

4.4.3 Uncertainty and time series' consistency

The uncertainty in iron and steel production (coke) is estimated at around ±20% in 2002.

4.4.4 Source -specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Documentation and archiving systems are under development and are implied in the inventory of the year 2002 emissions. At present, no verification has been carried out for the specific source-sector emissions.

4.4.5 Source -specific recalculations including changes made in response to the review process

None.

4.4.6 Source -specific planned improvements

No work plan for future improvements currently exists for this category.

4.5 Other Production (CRF 2.D)

4.5.1 Source category description

The non-fuel based CO_2 emissions the from pulp and paper industry as well as glass production are estimated to be negligible.

All NO_2 emissions from the pulp and paper industry are reported as fuel based emissions under CRF 1.

Catalytic cracking of oil is identified as a possible N_2O source in the IPCC Guidelines but no method or default emission factors are given. Catalytic cracking of oil is carried out at the refineries and, thus, this might be a possible emission source in Finland, too.

NMVOC emissions from the forest and food industries are included.

4.5.2 Methodological issues

NMVOC emissions from the forest industry are calculated at the Finnish Environment Institute. Activity data for the calculation is obtained from the Finnish Forest Industries Federation and the emission factors from the Finnish Forest Industries Federation, Report August 1996 and The Finnish Forest Industries Federation, Annual report 2001, Sawmills and board production.

NMVOC emissions from the food industry are calculated at the Finnish Environment Institute. Activity data for calculation of the NMVOC emissions from the food industries is obtained from Suomen Hiiva Oy, the National Research and Development Centre for Welfare and Health (Stakes), the Finnish Food and Drink Industries' Federation, the Plant Production Inspection Centre (KTTK) and from the Finnish Fisheries Research Institute. The emission factors are taken from the NPI (1999), Joint EMEP/Corinair Atmospheric Inventory Guidebook (2001) and YTV (1995).

All **SO_2 emissions** of different sulphur compounds are calculated as SO_2 equivalents.

The calculation methods are consistent with the IPCC Guidelines.

4.5.3 Uncertainty and time series' consistency

No uncertainty estimation for non-fuel based CO_2 emissions has been carried out due to missing emission data.

4.5.4 Source -specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. The quality system is under development and will be implied in the inventory of the year 2003 emissions.

At present, no verification has been carried out for the specific source-sector emissions.

4.5.5 Source -specific recalculations including changes made in response to the review process

No recalculations have been made to the previous inventories.

4.5.6 Source -specific planned improvements

No work plan for future improvements currently exists for this category.

4.6 Production of Halocarbons and SF_6 (CRF 2.E)

Halocarbons and SF_6 are not produced in Finland.

4.7 Consumption of Halocarbons and SF_6 (CRF 2.F)

Inventories of F-gases are documented in detail in two reports. Documentation for the 2003 submission (Oinonen 2003) is available for downloading at http://environment.fi/. Please search the site using keyword SYKEmo278. Documentation for current (2004) submission is forthcoming, available via email from author (teemu.oinonen@environment.fi).

These documents should facilitate a detailed review of the F-gases inventory. What follows in this chapter, then, is a general summary of the 2004 submission.

4.7.1 Source category description

Historically, HFC, PFC and SF_6 (for short: F-gases) emissions have been very low in Finland. This is explained by the absence of certain large industrial point sources that account for most of the F-gases emissions globally. First of all, F-gases are not produced in Finland, which means that there are no fugitive emissions from manufacturing. Moreover, there is no manufacturing of other fluorinated gases, such as HCFCs, that could lead to by-product emissions (e.g. HFC-23 from HCFC-22 manufacturing). Other point sources that have generated plenty of emissions elsewhere, but are absent in Finland, include primary aluminium and magnesium industry.

F-gases emissions from the Finnish sources thus follow from consumption of these gases in various applications:

- SF_6 used as a cover gas in magnesium die casting
- SF_6 used in electrical equipment (gas insulated switchgear and circuit breakers)
- SF_6 used in "semi-prompt applications" (running shoes, windows)
- HFCs, PFCs and SF_6 used in semiconductor manufacturing
- HFCs and PFCs used as refrigerants in refrigeration and air conditioning equipment
- HFCs used as propellants in aerosols and one-component polyurethane foam
- HFCs used as blowing agents in manufacturing various kinds of polyurethane, extruded polystyrene and other foam products
- HFCs used as extinguishing agents in fixed fire fighting systems.

There has been no indication so far of HFC use as a solvent in Finland.

In the inventory the "semi-prompt" applications of SF_6 consist of SF_6 emitted from shoes. The contribution of other "semi-prompt" applications to Finnish emissions of SF_6 was considered negligible and these sources were not included in the inventory.

Emissions from refrigeration and air conditioning are reported as a single figure for all of the refrigeration and air conditioning sub-categories (domestic, commercial, industrial, mobile, etc.). This follows from a project finished in 2002 that looked for ways of reducing the companies' reporting burden. Based on this project's results, it is clear that the companies do not have statistics available for the disaggregated reporting, or, that such reporting would entail an excessive reporting burden. It was also clear that a simplified survey form yielded better response activity.

The sub-category of emissions from aerosols also includes one-component polyurethane foam cans (OCF), a very aerosol-like product. These products have been treated as aerosols in the Finnish inventory. This practice predates the Good Practice Guidance. In the Good Practice Guidance, OCF is discussed together with other foam types, and the methodology is slightly different from that applied to aerosols. It has been decided not to change the practice of including OCF in the aerosols sub-source category, because this would require recalculation of both the aerosol and foam time series, and because recalculation would lead to insignificant differences in the total Finnish emissions of F-gases.

In reporting the results, HFC-23 from refrigeration and air conditioning, HFCs used as extinguishing agents, SF_6 in shoes, SF_6 in magnesium die-casting and HFCs, PFCs and SF_6 used in semiconductor manufacturing have been aggregated into one source category. This is to protect the sources of the data (see Section 1.6 on confidentiality).

4.7.2 Methodological issues

Summary of the methods used in preparing the F-gases inventory is presented in Table 6. Please note that detailed descriptions of the methodologies for each source category are described in separate documents (Oinonen 2003, 2004). The documents describe, among other things, how activity data were gathered and how the uncertainties were quantified.

TABLE 6. Summary of methods used in the F-gases inventory.

Source category	Methods used	Reference	Notes
Magnesium die-casting	Direct reporting method, Tier 1a	Palmer 2000, p. 3.48; Anon. 1997, p. 2.47	Tier 1b is not applicable to this category because all SF_6 used is imported in bulk. Emissions from this source are not reported separately due to confidentiality.
Electrical equipment	Tier 3c (country-level mass-balance), Tier 1b	Olivier & Bakker 2000, p. 3.56; Anon. 1997, p. 2.48 and section 3.1 of Oinonen (2003)	Tier 1a estimates can not be calculated for this source because of lack of historical data. Tier 1b estimates have been calculated, however, based on survey and emissions data, cf. section 3.1 of Oinonen (2003).
Running shoes	Method for adiabatic property applications, Tier 1b	Olivier & Bakker, p. 3.65; Anon. 1997, p. 2.48	Tier 1a is not applicable to this category because all SF6 used is imported not in bulk, but in products (i.e. shoes). Emissions from this source are not reported separately due to confidentiality.
Semiconductor manufacturing	Tier 1, Tier 1a	Bartos & Burton 2000, p. 3.72; Anon. 1997, p. 2.47	Tier 1b is not applicable to this category because all gases used are imported in bulk.
Refrigeration and air conditioning	Top-down Tier 2, Tier 1a, Tier 1b	Forte et al. 2000, pp. 3.100–3.106; Anon. 1997, p. 2.47–2.50	Tier 2 top-down method is used for all sources in this category, both stationary and mobile. Data is not collected for separate sub-categories because such statistics are either not available or the preparation of such statistics would entail a very high reporting burden on companies. In the 2004 submission, the refrigerant emissions model was updated to include disposal emissions (see Oinonen 2004).
Aerosols and one component foam	Tier 2, Tier 1a, Tier 1b	Forte et al. 2000, p. 3.85; Anon. 1997, p. 2.47–2.50	One component foam cans are treated as aerosols in this inventory, cf. section 2.3.6 of Oinonen (2003). MDIs are not reported separately from other aerosols due to confidentiality.
Foam blowing	Tier 2, Tier 1a, Tier 1b	Forte et al. 2000, p. 3.93 and section 2.3.7 of this report; Anon. 1997, p. 2.47–2.50	Revised 1996 IPCC Guidelines and the Good Practice Guidance give little advice on how to model the effect of leakage from products and the annually installed new foam products on HFCs banked in foams. See section 2.3.7 of Oinonen (2003) on how these effects were modelled.
Fixed fire fighting systems	Tier 2, Tier 1a, Tier 1b	Forte et al. 2000, p. 3.115; Anon. 1997, p. 2.47–2.50	Emissions from this source are not reported separately due to confidentiality.

4.7.3 Uncertainty and time series consistency

Both the level and the trend uncertainties have been quantified for sub-source categories shown in Table 4, and also for overall F-gases emissions. The inventory was improved based on the first uncertainty quantification in 2003 submission. That analysis suggested that survey coverage should be improved if better accuracy is desired. In the 2004 submission, the surveys were expanded from some 250 to 1000 respondents. This resulted in a 65% reduction in the F-gases inventory uncertainty (Oinonen 2004).

4.7.4 Source-specific QA/QC and verification

The formal QA/QC system is still under development. Statistics Finland is leading the work in project that commenced in October 2003.

In order to minimise errors in filling the CRF tables, the following procedure was followed:

1. A checklist of data reported in the CRF was prepared (Appendix B in Oinonen 2004)
2. Following the list item by item, data from spreadsheets used in calculating emissions were transferred to a separate list (Appendix C in Oinonen 2004)
3. From this list, items were transferred to the CRF

The consistency of data were checked in both steps from 1 to 2, and from 2 to 3.

A check was also made that the total actual level of emissions, 528.12 Gg CO_2-eq., was equal in both tables 2(I)s2 and 10s4. Moreover, a similar check on potential emissions level, 1325.04 Gg CO_2-eq., indicated agreement between tables 2(I)s2 and 2(II)s2. Finally, a check on the potential and actual emissions ratios indicated consistency of reported information.

Note that some data was grouped to prevent disclosure of confidential business information (see Section 1.6 and Oinonen 2003). These quantities were edited into the formulas of the following tables and cells:

- Table2(I)s2 cells F22, F18, H18, J18, E18, G18 and I18
- Table2(II)s2 cells O21, W18, W21, X21, O26, W26 and X9
- Table10s4 cells O7, O21, O29

It is hoped that the improved CRF will enable a more transparent inclusion of grouped data into the submission. Meanwhile, the confidential quantities are listed qualitatively in Appendix D of Oinonen 2004.

At present, the level of emissions have not been verified, but this is planned for the 2005 submission.

4.7.5 Source-specific recalculations including changes made in response to the review process

The 2004 submission does not contain recalculations related to F-gases. The 2003 submission did report recalculations (see Oinonen 2003).

4.7.6 Source-specific planned improvements

The level of F-gases emissions has not been verified. The issue will be looked into while preparing the 2005 submission.

4.8 Other (CRF 2.G)

No emission sources are included in this sector.

5 SOLVENT AND OTHER PRODUCT USE (CRF 3)

5.1 Overview of the sector

The only direct greenhouse gas source identified in the solvent and other product use sector is the use of N_2O in industrial, medical and other applications. In Finland, N_2O is used in hospitals and by dentists to relieve pain and for detoxification.

The main sources of NMVOC emissions in Finland is paint application while printing industry and domestic solvent use also contribute to the emissions. Emissions from the solvent and other product use sector are shown in Figure 10.

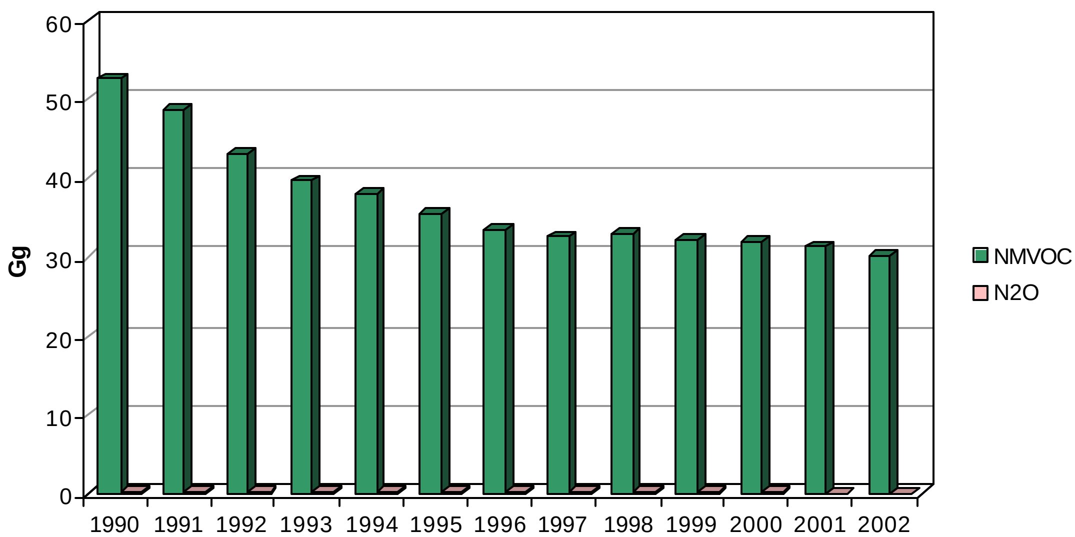

FIGURE 10. Emissions in the solvent and other product use sector 1990–2002.

5.2 Solvent and Other Product Use (CRF 3)

5.2.1 Source category description

In Finland N_2O is used in medical applications, as well as in some other specific applications, e.g. in industry. All used N_2O is imported.

Emission sources for the NMVOC compounds are paint application, degreasing and dry cleaning, chemical products, manufacture and processing: pharmaceutical industry, leather industry, plastic industry, textile industry, rubber conversion, manufacture of paints etc., and other solvent use: printing industry, preservation of wood, use of pesticides, glass and mineral wool enduction and domestic solvent use.

5.2.2 Methodological issues

The N_2O emissions are calculated by Statistics Finland. Tier 2 calculation method is consistent with the IPCC Guidelines. For estimation of N_2O emissions sales data is obtained from a few companies for the years 1990 and 1998. The emission estimation is based on assumption that all used N_2O is emitted to atmosphere the same year it is used. From 1999 onwards the data is partly estimated due to non-response.

The NMVOC emissions for CRF tables 3.A, 3.B, 3.C and 3.D are calculated at the Finnish Environment Institute:

3.A The emissions are based on emission calculation by the Association for Finnish Paint Industry and emissions data from the Regional Environment Centres' VAHTI database.

3.B The emission are based on emission data from the Regional Environment Centres' VAHTI database and on import of pure solvents and products containing chlorinated organic solvents and amounts of the solvent waste processed in hazardous waste treatment plants. The emission factor is an expert estimation at the VTT Technical Research Centre of Finland.

3.C The emissions are based on emission data in the Regional Environment Centres' VAHTI database and on questionnaires to small and medium size companies in textile, plastic and leather industry. The emission factors are based on expert estimations in the industries and at the Finnish Environment Institute.

3.D The emissions are based on emission data in the Regional Environment Centres' VAHTI database, on questionnaire to small and medium size presses and vegetable oil pressing plants and activity data from the Finnish Environment Institute's Chemicals Divisions database. The emission factors are country specific based on expert estimation at the Finnish Environment Institute's Chemicals Division. Emissions from domestic solvent use are based on emission calculation by the Finnish Cosmetics, Toiletry and Detergents Association.

5.2.3 Uncertainty and time series' consistency

The uncertainty in solvent and other product use is -34...+38% in 2002.

5.2.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Documentation and archiving systems are under development both at Statistics Finland and the Finnish Environment Institute and will be implied in the inventory of the year 2002 emissions.

At present, no verification has been carried out for the specific source-sector emissions.

5.2.5 Source-specific recalculations including changes made in response to the review process

No recalculations were made to the previous inventories.

5.2.6 Source-specific planned improvements

The quality of the activity data for N_2O emissions inventory will be improved.

6 AGRICULTURE (CRF 4)

6.1 Overview of the sector

Finland reports agricultural emissions from the following sources: CH_4 emissions from enteric fermentation in domestic livestock, N_2O emissions from manure management, direct N_2O emissions from agricultural soils, indirect N_2O emissions from nitrogen used in agriculture and CH_4 emissions from manure management. CO_2 emissions from agricultural soils are also reported under agricultural emissions (Pipatti 2001).

Agricultural key sources in 2001 identified by the IPCC Tier 2 method were CH_4 emissions from enteric fermentation, N_2O emissions from agricultural soils and N_2O emission from manure management (Monni & Syri 2003). In the year 1999 inventory analysis, also CO_2 emissions from agricultural soils was identified as a key source (Aaltonen et. al. 2001) (this category was not included in 2001 key source analysis).

Previous inventories in the agricultural sector have been made at the VTT Technical Research Centre of Finland (Pipatti 2001) with the assistance of the MTT Agrifood Research Finland (Kulmala & Esala 2000). Since the year 2001 the inventory has been made completely at the MTT Agrifood Research Finland and a systematic calculation system for the whole sector is currently under further development. Closer studies in some areas will be launched. Main focuses are the improved collecting of activity data, development of emission factors based on national data and enhancement of QA/QC measures.

Finnish agricultural greenhouse gas emissions in 2002 were 7.48 Tg CO_2 equivalents in total. The summary of agricultural emissions by source and gas is illustrated in Table 7 and Figure 11. The main agricultural sources of greenhouse gases in 2002 were agricultural soils emitting 3.28 Tg CO_2 equivalents nitrous oxide and 2.06 Tg CO_2 equivalents carbon dioxide in total.

TABLE 7. Finnish agricultural greenhouse gas emissions by source and gas in 1990-2002

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
CH_4						**Tg CO_2 equivalents**							
Enteric fermentation	1.87	1.79	1.74	1.74	1.73	1.63	1.64	1.66	1.62	1.59	1.58	1.56	1.56
Manure management	0.20	0.19	0.18	0.18	0.19	0.22	0.22	0.22	0.22	0.21	0.21	0.20	0.20
N_2O													
Agricultural soils	4.27	3.98	3.64	3.69	3.68	3.75	3.61	3.52	3.44	3.33	3.38	3.34	3.28
Manure management	0.55	0.53	0.52	0.52	0.52	0.47	0.46	0.46	0.44	0.42	0.41	0.40	0.38
CO_2													
Organic soils	1.62	1.60	1.58	1.55	1.53	1.38	1.36	1.34	1.31	1.29	1.27	1.25	1.23
Mineral soils	0.97	0.78	0.41	0.22	0.09	–0.03	0.05	0.25	0.27	0.29	0.34	0.31	0.41
Liming	0.62	0.43	0.33	0.45	0.44	0.37	0.41	0.47	0.44	0.43	0.42	0.39	0.42
Total	**10.10**	**9.29**	**8.39**	**8.36**	**8.18**	**7.79**	**7.75**	**7.92**	**7.74**	**7.56**	**7.61**	**7.45**	**7.48**

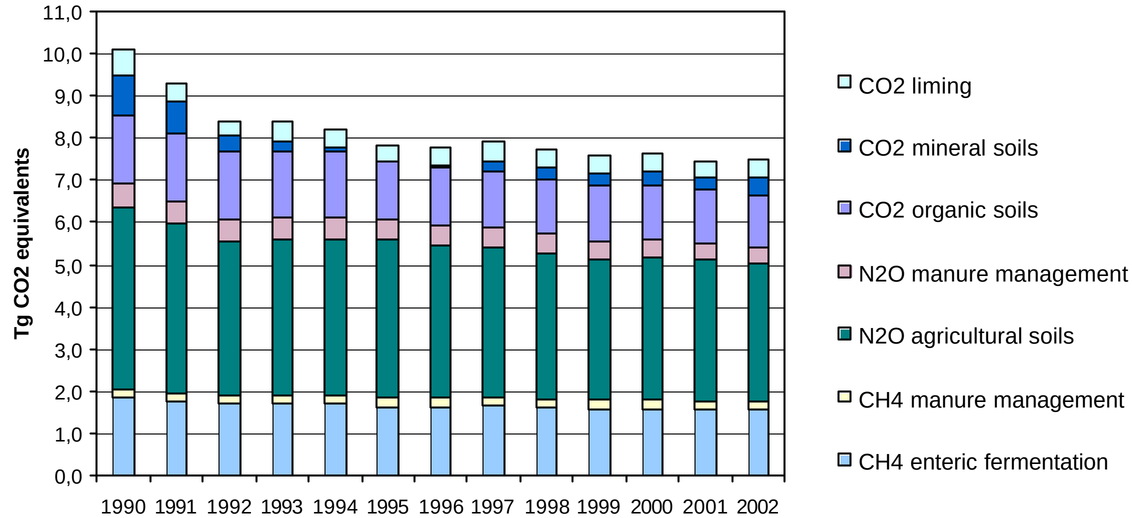

FIGURE 11. Finnish greenhouse gas emissions in agriculture in 1990–2002 by main source category and gas.

Greenhouse gas emissions from agriculture have declined over the period of 1990–2001. One reason for this is Finland's membership in the EU that resulted in changes in the economic structure followed by an increase in the average farm size and a decrease in the number of small farms (Pipatti 2001). Those changes caused also a decrease in the livestock numbers except for the number of horses that has increased in the recent years. The reduced use of nitrogen fertilisers and improved manure management resulting from the measures taken by the farmers as a part of an agro-environmental program aiming to minimise nutrient loading to water courses has also decreased the emissions. In 2002 there was a minor increase in total emissions compared to total emissions in 2001 mainly due to increase in CO_2 emissions from agricultural soils. Because of the uncertainty related to emissions from this source category this change could be considered almost negligible.

6.2 Enteric Fermentation (CRF 4.A)

6.2.1 Source category description

The emission sources cover domestic livestock. Finland reports emissions from cattle (including dairy cows, mother cows, heifers, bulls and calves), swine, horses, goats, sheep and reindeer.

6.2.2 Methodological issues

Calculation of emissions is based on methods described in the Revised 1996 IPCC Guidelines (IPCC 1996a) and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). **CH_4 emissions from enteric fermentation** of cattle have been estimated using the Tier 2 methodology. The average daily feed intake has been calculated from data on animal weight, daily weight gain etc. as in previous inventories. These input data have been obtained from agricultural experts. The method and the activity data acquisition are described in more detail in the references (Pipatti 2001; Pipatti et al. 2000; Pipatti 1997; Pipatti et al. 1996; Savolainen et al. 1996). The method is consistent with the IPCC Guidelines. For the other animal types the Tier 1 method and the default values given in the IPCC Guidelines have been used. CH_4 emissions from enteric fermentation of reindeer have been calculated on basis of Finnish literature (Nieminen et al. 1998).

Activity data have been collected from annual agricultural statistics (animal numbers, milk production for dairy cows) and surveys (monthly and annual publications by the Information Centre of the Ministry of Agriculture and Forestry). Some information has been received from the "Matilda" database of the Ministry of

Agriculture and Forestry, and agricultural experts. Summary of the emission factors used in the 2002 inventory is presented in Table 8.

TABLE 8. Methods and emission factors used in calculating methane emissions from enteric fermentation.

Animal category	Method	Type of EF	EF (kg CH_4/head/year)
Dairy cows	IPCC Tier 2	National	115.22
Mother cows	IPCC Tier 2	National	66.04
Bulls	IPCC Tier 2	National	60.15
Heifers	IPCC Tier 2	National	61.24
Calves	IPCC Tier 2	National	25.08
Swine	IPCC Tier 1	IPCC default	1.50
Sheep	IPCC Tier 1	IPCC default	8.00
Goats	IPCC Tier 1	IPCC default	5.00
Horses	IPCC Tier 1	IPCC default	18.00
Reindeer	IPCC Tier 1	National	8.85

6.2.3 Uncertainty and time series' consistency

The uncertainty in enteric fermentation of domestic animals is around ±30% in 2002. The uncertainty estimates of activity data are based on national information, and the uncertainty estimates for emission factors are mainly IPCC default uncertainties. Total uncertainty in agriculture sector is -33...+43%. These estimates do not cover uncertainty in CO_2 from agricultural soils.

Part of the input data is not found in the agricultural statistics or surveys and is therefore based on expert knowledge. As the sources of data do not vary between years the time series can be considered consistent. Numerical estimates of uncertainty for all emission sources are presented in Monni & Syri (2003).

The emission factor used for reindeer is national and was calculated on basis of literature and comments of an expert of reindeer nutrition (Nieminen et.al. 1998; M. Nieminen, pers. comm.). The value is very preliminary and needs to be studied further. There has been discussion with Sweden and Norway concerning the reindeer emission factor, and co-operation in developing a common emission factor in the future is recommended by all parties.

6.2.4 Source -specific QA/QC and verification

Calculation of greenhouse gas emissions in the agricultural sector is currently carried out at the MTT Agrifood Research Finland. The QA/QC in the agricultural sector is still under development but some measures have been taken. Collecting of the activity data and documentation of the method have been improved. Some activity data has been compared to previously reported and a few corrections have been made. The importance of careful documentation of all the activity data sources, calculation methods and changes compared to the previous inventory has been noticed and will be further developed in the future.

6.2.5 Source -specific recalculations including changes made in response to the review process

In 2002 inventory no recalculation has been made. Recalculation will be made in this source category if the methodology will change in the future.

6.2.6 Source -specific planned improvements

The time series concerning the activity data has been improved but some of the values may still need fine-tuning and improvement. An idea of changing the method so that it would be based on the feed consumption of cattle instead of estimating this indirectly from the data on animal weight, daily weight gain etc. has been put forward by the VTT Technical Research Centre of Finland and will be further examined at the MTT Agrifood Research Finland.

6.3 Manure Management (CRF 4.B)

6.3.1 Source category description

The emission sources cover **management of manure from domestic livestock**. Finland reports emissions from cattle (including dairy cows, mother cows, heifers, bulls and calves), swine, horses, goats, sheep and poultry.

6.3.2 Methodological issues

Calculation of **methane emissions** is based on methods described in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996a) and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Penman et al. 2000). Tier 2 methodology for all animal categories has been used. Calculation of the emissions is based on annual agricultural statistics (animal numbers, milk production for dairy cows) and surveys (MKL 1993; Seppänen & Matinlassi 1998). Additional information has been received from agricultural experts. VS (volatile solid excretion) values for cattle have been calculated from feed intake values obtained from the calculations on emissions from enteric fermentation (Pipatti 2001). Other input data used are the IPCC default values. The method and activity data acquisition is described in more detail in the references (Pipatti 2001; Pipatti et al. 2000; Pipatti 1997; Pipatti et al. 1996; Pipatti 1994). No changes in the existing methods have been made in the 2002 inventory. The emission factors used in calculating the methane emissions from manure management are presented in Table 9.

TABLE 9. Emission factors used in calculating methane emissions from manure management.

Animal category	EF (kg CH_4/head/year)	Type of EF
Dairy cows	8.39	National
Mother cows	1.41	National
Bulls	4.37	National
Heifers	3.07	National
Calves	1.31	National
Swine	3.37	National
Sheep	0.19	National
Goats	0.12	National
Horses	1.42	National
Poultry	0.09	National

Calculation of **nitrous oxide** emissions from manure management is also based on the IPCC methods (IPCC 1996a; Penman et al. 2000) and is described in detail in Pipatti (2001). Annual average N excretion per head of animal is national data (Grönroos et al.1998) as well as the ratio of liquid/slurry to the total manure managed (Seppänen & Matinlassi 1998). IPCC default emission factors were used for each manure management system (Pipatti 2001).

6.3.3 Uncertainty and time series' consistency

The magnitude of methane emissions from manure management depends on the climate, temperature, animal type and feeding as well as the type of the manure management system used. IPCC default and also some national parameters have been used in calculating the emissions. More research will be needed in the future in developing national parameters. As the sources of data do not vary between years the time series can be considered consistent.

The magnitude of nitrous oxide emissions from manure management depend on the amount of nitrogen excreted in manure per animal as well as the proportion of manure managed in each manure management system. The values are based on national surveys and need to be updated regularly. IPCC default emission factors are used at the moment but field measurements are needed to ensure their suitability to Finnish climate conditions. As the sources of data do not vary between years the time series can be considered consistent.

The uncertainty in CH_4 emissions from manure management is estimated at around ±17%, and in N_2O emissions -82...+33%. The uncertainty estimate is negatively skewed, because it is assumed that some of the calculation parameters may overestimate N_2O emissions. It is likely that emissions are smaller than estimated, due to cold climate in Finland.

6.3.4 Source-specific QA/QC and verification

Calculation of greenhouse gas emissions in the agricultural sector is currently carried out at the MTT Agrifood Research Finland. The QA/QC in the agricultural sector is still under development but some measures have been taken. Collecting of the activity data and documentation of the method have been improved. Some activity data has been compared to previously reported and a few corrections have been made. The importance of careful documentation of all the activity data sources, calculation methods and changes compared to previous inventory has been noticed and will be further developed in the future.

6.3.5 Source-specific recalculations including changes made in response to the review process

In 2002 inventory no recalculation has been made but will be made later after possible corrections in calculation parameters.

6.3.6 Source-specific planned improvements

Annual or periodic data collection on e.g. the manure management systems need to be developed. Some of the input parameters in the calculation may need fine-tuning.

6.4 Rice Cultivation (CRF 4.C)

Rice cultivation does not occur in Finland.

6.5 Agricultural Soils (CRF 4.D)

6.5.1 Source category description

Carbon dioxide emissions from organic soils and liming are included in the inventory together with estimates of the changes in carbon stocks in mineral soils due to land-use change. The emissions are reported in category 4.D as they are caused by agricultural activities. They are also very analogous to the N_2O emissions from agricultural soils and they also share some activity data used in calculations (Pipatti 2001).

Direct N_2O emissions from nitrogen in mineral N fertilisers, animal manure, biological nitrogen fixation, crop residues, cultivation of Histosols and sewage sludge are included in the inventory. Nitrous oxide emissions from sewage sludge are reported as "other source" in the CRF tables. The emissions from nitrogen excreted to pasture range and paddocks by animals are reported under "animal production" in CRF tables.

Indirect emissions from atmospheric deposition of NH_4 and NO_x as well as from leaching and run-off of the applied or deposited nitrogen are included in the inventory.

6.5.2 Methodological issues

Calculation of emissions is consistent with the IPCC Guidelines and is based on activity data obtained from the annual agricultural statistics, publications, databases and agricultural experts. Both IPCC default and national values for emission factors and other parameters have been used. Activity data sources are presented in Table 10. No changes in the methodology compared to the previous inventories have been made.

TABLE 10. Activity data sources for calculating nitrous oxide and carbon dioxide emissions from agricultural soils.

Activity data	Source of information
Crop statistics	The Information Centre of the Ministry of Agriculture and Forestry
Data of sludge spreading	VAHTI database (Regional Environment Centres)
N excretion by animal types	Rural Advisory Centres, e.g. Grönroos et al. 1998
Data of animal waste management systems	Rural Advisory Centres, MKL 1993; Seppänen & Matinlassi 1998
Energy model for ammonia emission estimate	VTT Technical Research Centre of Finland, Savolainen et al. 1996, and agricultural experts
Amount of lime used in agriculture	Finnish Liming Society

N_2O emissions from soils

Nitrous oxide emissions from agricultural soils are calculated using the emission factors presented in Table 11. Direct emissions from sewage sludge are reported under "other source" in the CRF tables and direct emissions from N-excretion on pasture range and paddocks are reported under "animal production" in the CRF tables. Other parameters used for calculating nitrous oxide emissions from agricultural soils are presented in Table 12.

TABLE 11. Emission sources and emission factors used for calculating nitrous oxide emissions from agricultural soils.

Emission source	Emission factor	Reference
Direct soil emissions		
Synthetic fertilisers	0.0125 kg N_2O-N/kg N	Penman et al. 2000, p. 4.60, Table 4.17
Animal wastes applied to soils	0.0125 kg N_2O-N/kg N	Penman et al. 2000, p. 4.60, Table 4.17
N-fixing crops	0.0125 kg N_2O-N/kg dry biomass	Penman et al. 2000, p. 4.60, Table 4.17
Crop residues	0.0125 N_2O-N/kg dry biomass	Penman et al. 2000, p. 4.60, Table 4.17
Cultivation of Histosols	8 kg N_2O-N/ha/a	Penman et al. 2000, p. 4.60, Table 4.17, Klemedtsson et al. 1999
Indirect soil emissions		
Atmospheric deposition	0.01 kg N_2O-N/kg NH_4-N & NO_x-N deposited	Penman et al. 2000, p. 4.73, table 4.18
Nitrogen leaching and run-off	0.025 kg N_2O-N/kg N/a	Penman et al. 2000, p. 4.73, table 4.18
Animal production		
N-excretion on pasture range and paddock	0.020 kg N_2O-N/kg N/a	IPCC 1996a, p. 4.97
Other sources		
Sludge spreading	0.0125 kg N_2O-N/kg N load	IPCC 1996b, p. 4.37, EF_1

TABLE 12. Other parameters used for calculating nitrous oxide emissions from agricultural soils.

Parameter	Abbreviation	Value	Reference
Fraction of N input that is lost through leaching or runoff	$Frac_{LEACH}$	0.15	Pipatti 2001; Pipatti et al. 2000; Rekolainen et al.1995
Fraction of N input that volatilises as NH_3 and NO_x from synthetic fertilisers.	$Frac_{GASF}$	0.006	Pipatti 2001; Keränen & Niskanen 1987
Fraction of manure N input that volatilises as NH_3 and NO_x	$Frac_{GASM}$	0.31	Energy model for ammonia emission estimate (VTT Technical Research Centre of Finland), Savolainen et al.1996

CO_2 emissions from soils

Calculation of CO_2 emissions from mineral soils is based on changes in the carbon stocks resulting from changes in land use in the period of 20 years. The area of agricultural soils is calculated from the annual agricultural statistics published by the Ministry of Agriculture and Forestry. Determination of the area of organic soils is based on analyses of soil testing results (Finnish Soil Analysis Service) made at the MTT Agrifood Research Finland. (Myllys 2002, pers. comm.). Organic soils have been divided into peat soils and other organic soils according to their content of soil organic matter. Emissions from peat soils and other organic soils have been calculated using both the IPCC default and national emission factors (Table 13). The emissions from liming have been calculated using the IPCC method and data from the Finnish Liming Association.

TABLE 13. Emission factors used for calculating CO_2 emissions from organic soils.

Emission source	EF (Mg C/ha/a)	Reference
Peat soils Soil organic matter content > 40% (w)		
Pasture	2	National by Berglund 1989
Upland crops	4	National by Nykänen et al. 1995
Other organic soils Soil organic matter content 20–40% (w)		
Pasture	0.5	National by Berglund 1989
Upland crops	1	IPCC default, IPCC 1996b, p. 5.29

6.5.3 Uncertainty and time series' consistency

The new uncertainty analysis (Monni & Syri 2003) does not include CO_2 from agricultural soils. According to Aaltonen et al. (2001) the uncertainty estimate of CO_2 emissions from agricultural soils was -104…+104% in 1999. Uncertainties in this source category arise from both the natural variability of emissions, uncertainties in the estimated areas of different soil and land-use types as well as uncertainty in the emission factors.

There is great need to re-build the calculation model used in calculating CO_2 emissions from agricultural soils. Also, the source data (soil statistics) and emission factors needs to be checked and updated.

The uncertainty in N_2O emissions from agricultural soils is ±56% for direct emissions and -82...+340% for indirect emissions. Emission factors for indirect emissions are highly uncertain due to natural variability of the emission source and lack of knowledge of emission generating process. Total uncertainty in N_2O from agricultural soils is -52...+69%.

$Frac_{LEACH}$ for which the use of the default was estimated to lead to an overestimation of the emissions by a factor of 2; support for the value used can be found e.g. in Rekolainen et al. (1995).

6.5.4 Source -specific QA/QC and verification

Calculation of greenhouse gas emissions in the agricultural sector is currently carried out at the MTT Agrifood Research Finland. The QA/QC in the agricultural sector is still under development but some measures have been taken. Collecting of the activity data and documentation of the method has been improved. Some activity data have been compared to previously reported and a few corrections have been made. The importance of careful documentation of all the activity data sources, calculation methods and changes compared to previous inventory has been noticed and will be further developed in the future.

6.5.5 Source -specific recalculations including changes made in response to the review process

In 2002 inventory no recalculation has been made but will be done later when the complete check of the model and related data has been done.

6.5.6 Source -specific planned improvements

The suitability of the IPCC default emission factors for the Finnish conditions is questioned as the climatic conditions and agricultural practices differ very much from those from which the default values have been derived. Country specific emission factors are used in the estimates to a certain extent but more research is still needed in the future. Further development of national emission factors will continue at the MTT Agrifood Research Finland. A project is planned which will give new information about changes in the soil carbon stocks in Finland. The project will also yield new information about the area of organic soils in Finland.

The current guidelines are not considered logically or scientifically correct in all aspects considering the estimation of N_2O emissions. Also the development of the IPCC method in determining land use classifications for organic soils needs further examination.

Crop residue nitrogen of certain vegetable and fruit crops will be included into the calculations in the future.

6.6 Burning of Savannas (CRF 4.E)

Burning of savannas does not occur in Finland.

6.7 Field Burning of Agricultural Residues (CRF 4.F)

Field burning of agricultural residues is taking place in Finland only occasionally on small scale and the emissions from this source are estimated to be negligible.

7 LAND-USE CHANGE AND FORESTRY (CRF 5)

7.1 Overview of the sector

The CO_2 balance of the trees from 1990 to 2002 is presented in Table 14 and Figure 12. The annual increment of trees has increased almost steadily wherefore the CO_2 uptake has also increased. The total drain of trees is very much affected by commercial fellings and the global market situation. The demand of timber products was low in the beginning of 1990's wherefore fellings were also at low level and the CO_2 sink of trees high. The fellings in the end of 1990's were exceptionally high. The total drain of the years 1994 and 1995 are nearer to a long-term average. Strong fluctuation in the CO_2 sink in the 1990's is very much affected by these facts.

TABLE 14. Carbon dioxide uptake and release of trees 1990–2002.

Year	Tg CO_2		
	Uptake	Release	Balance
1990	95.9	72.1	23.8
1991	96.8	58.6	38.2
1992	98.6	66.7	31.9
1993	99.5	70.4	29.1
1994	97.8	80.6	17.3
1995	97.8	83.1	14.7
1996	98.0	77.0	21.0
1997	98.6	85.9	12.6
1998	100.1	90.4	9.7
1999	101.3	90.4	10.8
2000	103.1	91.1	12.0
2001	105.1	88.2	16.9
2002	107.5	89.5	18.1

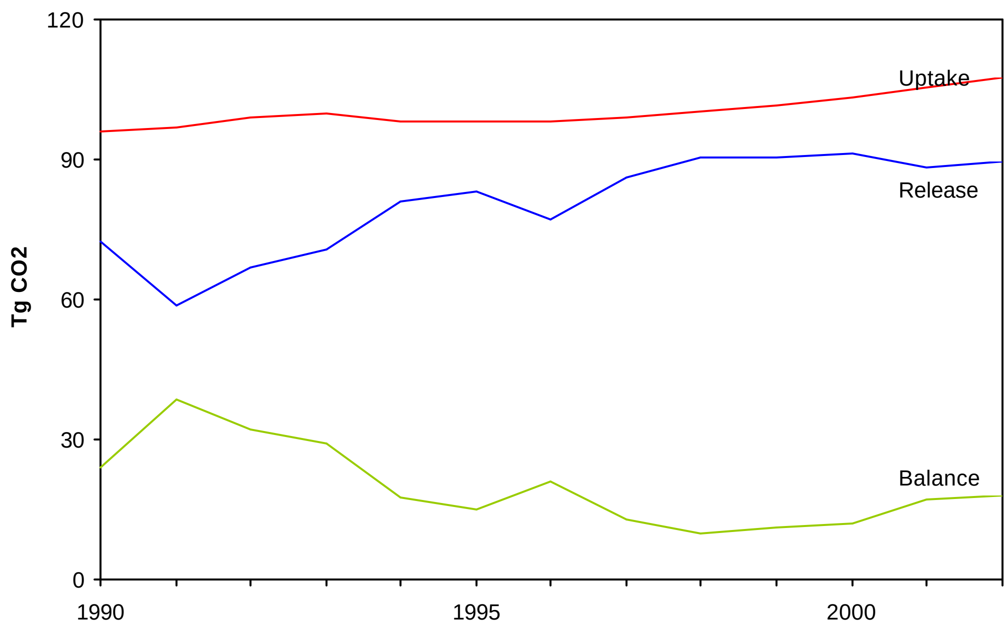

FIGURE 12. Carbon dioxide uptake and release of trees in Finland 1990–2002.

7.2 Changes in Forest and Other Woody Biomass Stocks (CRF 5.A)

7.2.1 Source category description

Emissions arise from tree fellings, harvesting and unrecovered natural losses, uptakes are caused by tree growth. Balance of forest growth has been positive throughout the observing periods e.g. forests act as CO_2 sink.

7.2.2 Methodological issues

The invention of the land use change and forestry sector is carried out by the Finnish Forest Research Institute (Metla). A national method is applied. It gives more accurate figures than the IPCC methodology.

Cutting statistics are collected by the Finnish Forest Research Institute, volume increment statistics are based on the Finnish National Forest Inventory (the Finnish Forest Research Institute).

The total annual drain estimates of forests are based on the statistics of cutting removals reported by the forest industry companies and collected by the Finnish Forest Research Institute, the estimates of household use of timber is based on enquires, the estimate of cutting waste is based on an extensive field study by the Finnish Forest Research Institute. The volume of natural losses is estimated in a study by the Finnish National Forest Inventory (Finnish Statistical Yearbook of Forestry 1999, Finnish Forest Research Institute).

The volume increment of the growing stock of trees is estimated using field measurements on sample plots of the Finnish National Forest Inventory (FNFI). The increment figures concern increment of the tree stem volume. An average increment of five years preceding the measurement time is applied. The FNFI progresses by regions and thus the data for the whole country comes from different years for different parts of the country (Tomppo 1999 and 2000b; Tomppo et al. 1997 and 1998). However, from 2004 on Finland will conduct national forest inventories annually for whole country. Conversion factors are applied for converting the tree stem volume for the whole tree biomass and carbon content (Karjalainen & Kellomäki 1996).

7.2.3 Uncertainty and time series' consistency

Total drain figures (corresponding emissions of CO_2) are estimated annually and are considered to be very accurate. Total increment figures (corresponding uptake of CO_2) are updated annually but the figures for different parts of the country come from different years. From the year 2004 on the annual inventories will cover the whole country. The averages of increments of five years preceding the measurement year are applied. This is a commonly used practice in forest inventories. The reliability figures can be assessed by means of statistical methods (Tomppo 1999 and 2000a).

7.2.4 Source-specific QA/QC and verification

New biomass allocation models with reliability estimates are under development and will be in use in 2005. The reliability figures both for sinks and sources of growing stock of trees will be developed and presented using that information.

7.2.5 Source-specific recalculations including changes made in response to the review process

The figures are updated annually.

7.2.6 Source-specific planned improvements

The real annual variation of the increment of trees is of a magnitude plus minus 20%. It is caused by climatic variation and biological cycles of trees. The use of five years instead of one reduces this variation which is not essential for the carbon balance budgeting. The new carbon allocation models with error estimates are under development and will be ready by 2005.

7.3 Forest and Grassland Conversion (CRF 5.B)

7.3.1 Source category description

Emission sources for the category cover deforestation (Forest land conversion to other land use). The country specific calculation method is consistent with the IPCC Guidelines.

7.3.2 Methodological issues

Activity data figures for calculation of the emissions are indirectly included in the forest tree biomass change figures given by the Finnish Forest Research Institute and the Finnish National Forest Inventory (the Finnish Forest Research Institute). The calculation method and applied emission factors are as in Changes in Forest and Other Woody Biomass Stocks.

7.3.3 Uncertainty and time series' consistency

The error estimates for the increment of the tree stem volume are available. The error estimates for the total tree biomass, biomass of increment and biomass of drain are under development. The consistency over time is good due to the fact that the same method has been used.

7.3.4 Source-specific QA/QC and verification

See Section 7.2.4.

7.3.5 Source-specific recalculations including changes made in response to the review process

No recalculations are needed.

7.3.6 Source-specific planned improvements

New carbon allocation models of trees with error estimates are under development.

7.4 Abandonment of Managed Lands (CRF 5.C)

7.4.1 Source category description

Emission sources cover natural regrowth of abandoned managed lands.

7.4.2 Methodological issues

The activity data are indirectly included in the forest tree biomass change figures given by the Finnish Forest Research Institute and the Finnish National Forest Inventory (the Finnish Forest Research Institute). For the calculation method and emission factors, see Changes in Forest and Other Woody Biomass Stocks. The country specific method is consistent with the IPCC Guidelines.

7.4.3 Uncertainty and time series' consistency

See Section 7.3.3.

7.4.4 Source -specific QA/QC and verification

See Section 7.2.4.

7.4.5 Source -specific recalculations including changes made in response to the review process

See Section 7.3.4.

7.4.6 Source -specific planned improvements

See Section 7.3.5.

7.5 CO_2 Emissions and Removals from Soil (CRF 5.D)

7.5.1 Source category description

Emission sources in this category include forest soil; for agricultural soils, see Section 6.5.

Emissions or removals from forest soils are not reported at the moment. The changes in the carbon content of the forest soil are slow. Many factors, both human induced (e.g. forest management) and not human induced, affect the changes.

7.5.2 Methodological issues

A method to estimate changes in the carbon content of forest soil is under development at the Finnish Forest Research Institute. The method is ready and the estimates are available by the end of year 2005.

7.5.3 Uncertainty and time series' consistency

Annual changes in the carbon content of forest soil are very small and their estimates may be unreliable. The estimates of the annual changes are not necessarily due to the slow processes, either.

7.5.4 Source -specific QA/QC and verification

See Section 7.2.4.

7.5.5 Source -specific recalculations including changes made in response to the review process

No recalculations are carried out.

7.5.6 Source -specific planned improvements

See Section 7.5.1.

7.6 Other (CRF 5.E)

There are no emission sources to be included in this category.

8 WASTE (CRF 6)

8.1 Overview of the sector

Solid waste disposal on land (landfills and dumps) causes relatively large CH_4 emissions in Finland while emissions from wastew ater treatment are smaller. CH_4 emissions from landfills are the most important greenhouse gas emissions in the waste sector. During the 1990's these emissions have decreased by more than 25%. The decrease has been mainly due to the preparation and implementation of the new waste law in Finland in 1994. At the beginning of the 1990's, around 80% of the generated municipal waste was taken to solid waste disposal sites (landfills). After the implementation of the new waste law, minimisation of waste generation, recycling and reuse of waste material and alternative treatment methods to landfills have been endorsed. Similar developments have occurred in the treatment of industrial waste, and municipal and industrial sludges. CH_4 emissions from solid waste disposal on land have been identified as a key source in Finland. Emission trend in the waste sector in CO_2 equivalents is presented in Figure 13.

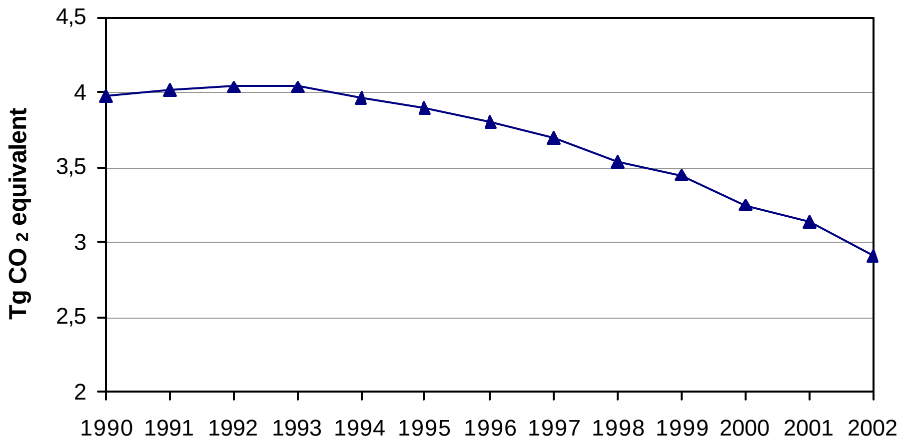

FIGURE 13. Finnish emissions trends in the waste sector 1990–2002.

8.2 Solid Waste Disposal on Land (CRF 6.A)

8.2.1 Source category description

The emission sources include solid waste disposal sites including solid municipal, industrial, construction and demolition wastes and municipal (domestic) and industrial sludges.

8.2.2 Methodological issue s

CH_4 emissions from solid waste disposal on land have been calculated at the Finnish Environment Institute using the Tier 2 method given in the IPCC Good Practice Guidance and in the Revised (1996) Guidelines (first order decay method) and using national and IPCC emission factors.

Activity data for landfilled waste is obtained from the Finnish Environment Institute using both the VAHTI database information and information from the Register of Landfill Sites. Also data from publications of Statistics Finland and the Ministry of the Environment are used. Data on landfill gas recovery is obtained from the Finnish Biogas Plant Register.

The NMVOC emissions are based on expert estimation (Arnold et al. 1998).

Emission factors are either country specific or IPCC default values as follows:

D	Methane correction factor (MCF) is 1
CS	Degradable organic carbon in municipal solid waste (DOC) 0.20 (based on waste composition in 1990)
CS	Expert knowledge. Fraction of DOC dissimilated, DOC_f = 0.50 (mean temperature in landfills 10–15ºC)
D	Fraction of methane in landfill gas, F = 0.5
CS	Expert knowledge: Oxidation factor (OX) 0.1
D/CS	k_1 = 0.2 (Food waste in MSW and sludges) k_2 = 0.03 (wood waste in MSW and in construction and demolition waste, paper waste containing lignin in MSW) k_3 = 0.05 (industrial solid waste and other fractions of MSW than above)

Equation 5.1 in the Good Practice Guidance has been used so that the term MCF(t) has substituted for the term MCF(x) in the calculation of $L_0(x)$. It has been thought that the situation in year t defines the MCF to be used for the emissions caused by waste amounts landfilled in the previous years also. In Finland this is valid for closed landfills also (which have been unmanaged when used) because all the closed landfills have been covered at present.

Estimations of waste amounts before 1990 are presented in Tuhkanen (2002).

8.2.3 Uncertainty and time series' consistency

The uncertainty in Solid Waste Disposal on Land is estimated by applying probabilistic calculation to the First Order Decay model. Uncertainty estimates are based on expert judgement, IPCC default values, and to a small extent, measurement data. Total uncertainty is ±43%. The most important factors affecting uncertainty are the fraction of methane in landfill gas, waste degradation coefficients (slow and default) and fraction of degradable organic carbon dissimilated.

The uncertainties in the estimates on CH_4 emissions from waste are large. The data on composition and amount of waste landfilled is still often based on rough estimates and, when looking at the past composition and amount of waste landfilled, the lack of data is even greater. Statistics on both municipal and industrial waste management are currently improving, and future emissions will at least to some extent be based on more reliable data. The improved statistics are assumed to improve the estimation accuracy of the emissions for the years from 1997 onwards.

8.2.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Documentation and archiving systems are under development at the Finnish Environment Institute and are implied in the inventory of the year 2002 emissions.

At present, no verification has been carried out for the specific source-sector emissions.

8.2.5 Source-specific recalculations including changes made in response to the review process

There were no recalculations to the previous years.

8.2.6 Source-specific planned improvements

The activity data before 1990 for waste as well as the waste composition data for MSW may be reviewed if better information is available.

8.3 Wastewater Handling (CRF 6.B)

8.3.1 Source category description

The emission sources cover municipal (domestic) and industrial wastewater handling plants and uncollected domestic waste waters for CH_4 emissions.

N_2O emissions are generated from nitrogen input of fish farming as well as domestic and industrial wastewaters into waterways.

NMVOC emissions from wastewater handling are included.

8.3.2 Methodological issues

A national methodology that corresponds to the methodology given in the Revised (1996) Guidelines is used in estimation of the **CH_4 emissions**. The emissions from municipal wastewater treatment are based on the BOD_7 load of the wastewaters. The BOD_7 measurements are converted to BOD_5-load by factor 0.8547. The emissions from industrial wastewater treatment are based on the COD load. These DC values of wastewaters with shared methane conversion factors have been used for both wastewater and sludge handling. The emission estimate is very uncertain as parameters are based on expert opinions.

The IPCC Guidelines have only two default values for the methane conversion completely aerobic or anaerobic. There are no plant specific measurements for the degradable organic component of the sludge in Finland. Especially for domestic wastewater there are good measurement results for DC of wastewaters in Finland. DC values of wastewaters with shared methane conversion factors have been used for both wastewater and sludge handling. The estimated methane conversion factors for collected wastewater handling systems (industrial and domestic) are low in Finland because the handling systems included in the inventory are either aerobic or anaerobic with complete methane recovery. The emission factors mainly illustrate exceptional operation conditions. For uncollected domestic waste waters the Check method with the default parameters (IPCC Good Practice Guidance) is used.

Activity data is based on

- municipal (domestic) wastewaters and BOD (BOD_7) value of the wastewater from the Finnish Environment Institute using both VAHTI database and the Water and Sewage Works Register and population (Check method);
- industrial wastewaters, COD value of the wastewater from the Finnish Environment Institute using both VAHTI database and the Register for industrial Water Pollution Control.

Estimates are based on expert knowledge.

Emission factors for municipal (domestic) wastewaters are IPCC default factors for maximum methane producing capacity B_o = 0.625 (= 2.5 · 0.25) kg CH_4/kg BOD and country specific expert knowledge for the methane conversion factor MCF = 0.01. For the industrial wastewaters the emission factor is the IPCC default for maximum methane producing capacity B_o = 0.25 kg CH_4/kg COD and country specific expert knowledge for the methane conversion factor MCF = 0.005.

In the Revised (1996) Guidelines a methodology to calculate the **N_2O emissions** from sewage is given in the Agriculture sector. The methodology is very rough and the N input into waterways is based on population data. In Finland, the N input from fish farming and from municipal and industrial wastewaters into the waterways is collected into the VAHTI database.

The NMVOC emissions are based on expert estimation (Arnold et al.1998).

8.3.3 Uncertainty and time series' consistency

The uncertainty in wastewater sector is -41...+46%. The total uncertainty is dominated by the uncertainty in N_2O emission factor.

8.3.4 Source -specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. Documentation and archiving systems are under development at the Finnish Environment Institute and are implied in the inventory of the year 2002 emissions.

At present, no verification has been carried out for the specific source-sector emissions.

8.3.5 Source -specific recalculations including changes made in response to the review process

There were no recalculations to the previous years.

8.3.6 Source -specific planned improvements

Wastewater treatment causes also N_2O emissions, although their importance is minor. In emission inventories the emissions have been estimated to be negligible. This assumption should be confirmed and the international development of the estimation methods for these emissions should be followed.

8.4 Waste Incineration (CRF 6.C)

Emissions of greenhouse gases CO_2, N_2O and CH_4 from Waste Incineration are reported in the energy sector.

8.5 Other (CRF 6.D)

There are no emission sources to be included in this category.

9 OTHER (CRF 7)

9.1 Overview of the sector

The sector includes emissions from feedstock and non-energy use of fuels.

9.2 Feedstock and Non-energy Use of Fuels (CRF 7)

9.2.1 Source category description

This source covers the CO_2 emissions from non-energy use of oil products and natural gas. At the moment there is not enough data available to identify the processes and actual source categories.

9.2.2 Methodological issues

The calculation method is the IPCC default method. The emissions are estimated at Statistics Finland based on activity data from the energy statistics and IPCC default emission factors. The emissions are calculated assuming that all non-stored carbon is combusted. This assumption may require more studies.

9.2.3 Uncertainty and timeseries' consistency

The uncertainty in non-energy use of fuels was estimates at around ±50% in 2002 based on expert knowledge on activity data and emission factor uncertainties.

9.2.4 Source-specific QA/QC and verification

Normal statistical quality checkings related to assessment of magnitude and trends have been carried out. The quality system is under development at Statistics Finland and will be implied in the inventory of the year 2002 emissions.

At present, no verification has been carried out for the specific source-sector emissions.

9.2.5 Source-specific recalculations including changes made in response to the review process

No recalculation has been carried out.

9.2.6 Source-specific planned improvements

The fractions of carbon stored (and carbon released) need to be checked. There is a possibility of double counting in the present inventory. The whole category will be checked and moved to the Industrial Processes in the future inventories.

10 RECALCULATIONS AND IMPROVEMENTS

A programme to identify and follow up the needs for methodological improvements in all source sectors has been established in Spring 2003. Summaries of the project descriptions compiled according to the source sectors are available in Finnish and in English according to the CRF categories. For air pollutants, summary of the development project is available in English.

Detailed source sector specific development description for both greenhouse gases and air pollutants is currently prepared for the Agriculture source sector, and under way for the other source sectors, too. The methodology development programme is coordinated by the Finnish Environment Institute.

10.1 Explanations and justifications for recalculations

CRF 1.A In the previous inventories the indirect N_2O emissions caused by nitrogen deposition due to NOx emissions in the energy sector were included in the emission estimates for the relevant sectors. That was reported as an exception to the IPCC Guidelines. Now these emissions have been re-moved from to inventory to increase transparency and comparability with other countries' inventories. Recalculation was made as a response to the centralized review (FCCC/WEB/IRI(3)/2002/FIN).

10.2 Implications for emission levels

CRF 1.A Due to recalculation in the CRF 1.A sector total CO_2 equivalent emissions are 312 – 463 Gg lower than in the previous submissions. This equals to -0,39 – -0,60 % annual change in total GHG emissions (without LULUCF).

10.3 Implications for emission trends, including time series consistency

CRF 1.A Recalculation has a relatively small effect on the emission trend. The change is highest (-463 Gg) in 1990 and smallest (-312 Gg) in 2001. The difference between these two figures is 150 Gg, which equals to 0,2 % of total GHG emissions in 2001. Recalculation has no implication on time series consistency.

10.4 Recalculations, including response to the review process, and planned improvements to the inventory

10.4.1 Recalculations

See 10.1.

10.4.2 Improvements in response to the review process

See 10.1

10.4.3 Planned improvements

The structure and contents of this report on the Finnish greenhouse gas emission inventory will be further developed and completed to meet the new UNFCCC reporting guidelines accepted by the COP8 in New Delhi.

CRF 1.A See Section 3.2.6.

CRF 1.B Calculation of the emissions from 1.B.1 Fugitive emissions from solid fuels will be made for the whole period since 1990 when improved data on areas of peatland and the emission factors is available.

The results of the NMVOC calculation model of the Finnish Environment Institute have to be updated into the CRF tables in category 1.B.2 Fugitive emission from oil and natural gas to years 1990–1999. Calculation of the fugitive emissions from distribution of oil and natural gas (which were estimated to be negligible) will be carried out according to the IPCC default methodology in the following inventories.

International bunkers:

Harmonisation of emission factors in the ILMARI and LIPASTO calculation models is underway. The results will be updated to the CRF tables as soon as possible.

CRF 2.A CO_2 emissions from the use of mineral products need to be estimated.

CRF 2.B Industrial emission sources for CH_4 and the suitability of the IPCC default emission factors should be studied further.

CRF 2.F The level of F-gases emissions has not been verified. The issue will be looked into while preparing the 2005 submission.

CRF 3 The quality of the activity data for N_2O emissions inventory will be improved.

CRF 4.A The time series concerning the activity data has been improved but some of the values may still need fine-tuning and improvement. An idea of changing the method so that it would be based on the feed consumption of cattle instead of estimating this indirectly from the data on animal weight, daily weight gain etc. has been put forward by the VTT Technical Research Centre of Finland and will be further examined at the MTT Agrifood Research Finland.

CRF 4.B Annual or periodic data collection on e.g. the manure management systems need to be developed. Some of the input parameters in the calculation may need fine-tuning.

CRF 4.D The suitability of the IPCC default emission factors for the Finnish conditions is questioned as the climatic conditions and agricultural practices differ very much from those from which the default values have been derived. Country specific emission factors are used in the estimates to a certain extent but more research is still needed in the future. Further development of national emission factors will continue at the MTT Agrifood Research Finland. A project is planned which will give new information about changes in the soil carbon stocks in Finland. The project will also yield new information about the area of organic soils in Finland.

The current guidelines are not considered logically or scientifically correct in all aspects considering the estimation of N_2O emissions. Also the development of the IPCC method in determining land use classifications for organic soils needs further examination. Crop residue nitrogen of certain vegetable and fruit crops will be included into the calculations in the future.

CRF 5.A The real annual variation of the increment of trees is of a magnitude plus minus 20%. It is caused by climatic variation and biological cycles of trees. The use of five years instead of one reduces this variation which is not essential for the carbon balance budgeting. The new carbon allocation models with error estimates are under development and will be ready by 2005.

CRF 5.B New carbon allocation models of trees with error estimates are under development.

CRF 5.C See Section 7.5.1

CRF 5.C See Section 7.3.5

CRF 6.A The activity data before 1990 for waste as well as the waste composition data for MSW may be reviewed if better information is available.

CRF 6.B Wastewater treatment causes also N_2O emissions, although their importance is minor. In emission inventories the emissions have been estimated to be negligible. This assumption should be confirmed and the international development of the estimation methods for these emissions should be followed.

CRF 7 The fractions of carbon stored (and carbon released) need to be checked. There is a possibility of double counting in the present inventory. The whole category will be checked and moved to the Industrial Processes in the future inventories.

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Annex 1. Energy balance sheets

Energy balance sheet 2002 (ktoe)

	Coal	Cr[illegible] NGL	Petroleum products	Natural gas	Nuclear energy	Hydro & wind power	Peat fuel	Wood and recycled fuels	Electricity	District heat & heat pumps	**Total**
Indigenous production	–	–	–	–	5 575	919	2 516	6 794	–	74	**15 877**
Imports	3 975	11 735	3 599	3 693	–	–	–	268	1 158	–	**24 428**
Exports	-1	–	-5 367	–	–	–	-9	-37	-132	–	**-5 547**
International marine bunkers	–	–	-641	–	–	–	–	–	–	–	**-641**
Stock Changes	525	168	126	–	–	–	-393	–	–	–	**426**
Total Primary Energy Supply	**4 500**	**11 903**	**-2 284**	**3 693**	**5 575**	**919**	**2 115**	**7 024**	**1 025**	**74**	**34 542**
Statistical Difference	0	206	-558	-2	–	–	–	–	–	–	**-354**
Electricity generation	-1 924	–	-55	-146	-5 575	-919	-689	-215	3 822	–	**-5 700**
Combined district heat and power	-1 174	–	-82	-1 511	–	–	-818	-397	1 281	2 098	**-603**
Co-generation electricity in industry	-46	–	-117	-222	–	–	-81	-964	1 055	–	**-373**
District heat production	-61	–	-221	-197	–	–	-80	-234	–	762	**-31**
Oil refinery	–	-12 109	11 866	–	–	–	–	–	–	–	**-243**
Coal transformation	-532	–	–	–	–	–	–	–	–	–	**-532**
Transmission and distributions losses	–	–	–	–	–	–	–	–	-253	-245	**-498**
TFC (total final energy)	**764**	**–**	**8 549**	**1 616**	**–**	**–**	**447**	**5 215**	**6 930**	**2 688**	**26 209**
Industry	762	–	1 456	1 482	–	–	422	4 035	3 834	267	**12 256**
Transport	–	–	4 462	22	–	–	–	–	51	–	**4 535**
Residential	2	–	847	29	–	–	12	1 006	1 556	1 505	**4 957**
Agriculture	–	–	657	14	–	–	12	112	73	10	**877**
Commerce and public services	–	–	364	29	–	–	2	62	1 258	907	**2 623**
Other consumption	–	–	483	–	–	–	–	–	159	–	**642**
Non-energy use	–	–	280	40	–	–	–	–	–	–	**320**

Energy balance sheet 2002 (TJ)

	Coal	Crude oil & NGL	Petroleum products	Natural gas	Nuclear energy	Hydro & wind power	Peat fuel	Wood and recycled fuels	Electricity	District heat & heat pumps	TOTAL
Indigenous production	–	–	–	–	233 400	38 470	105 336	284 431	–	3 080	**664 717**
Imports	166 438	491 335	150 665	154 620	–	–	–	11 200	48 470	–	**1 022 729**
Exports	-47	–	-224 724	–	–	–	-360	-1 552	-5 540	–	**-232 223**
International marine bunkers	–	–	-26 855	–	–	–	–	–	–	–	**-26 855**
Stock Changes	21 992	7 014	5 274	–	–	–	-16 436	–	–	–	**17 844**
Total Primary Energy Supply	**188 383**	**498 350**	**-95 640**	**154 620**	**233 400**	**38 470**	**88 540**	**294 079**	**42 930**	**3 080**	**1 446 212**
Statistical Difference	–	–	-2 512	-286	–	–	–	–	–	–	**-2 799**
Electricity generation	-80 534	–	-2 301	-6 113	-233 400	-38 470	-28 848	-8 998	159 998	–	**-238 666**
Combined district heat and power	-49 144	–	-3 435	-63 246	–	–	-34 244	-16 639	53 647	87 818	**-25 242**
Cogeneration electricity in industry	-1 907	–	-4 886	-9 285	–	–	-3 377	-40 342	44 176	–	**-15 621**
District heat production	-2 540	–	-9 261	-8 260	–	–	-3 351	-9 782	–	31 918	**-1 276**
Oil refinery	–	-506 988	496 809	–	–	–	–	–	–	–	**-10 179**
Coal transformation	-22 273	–	–	–	–	–	–	–	–	–	**-22 273**
Transmission and distributions losses	–	–	–	–	–	–	–	–	-10 588	-10 256	**-20 844**
TFC (total final energy)	**31 985**	**–**	**357 913**	**67 644**	**–**	**–**	**18 720**	**218 319**	**290 164**	**112 560**	**1 097 306**
Industry	31 895	–	60 957	62 028	–	–	17 660	168 919	160 510	11 163	**513 132**
Transport	–	–	186 833	900	–	–	–	–	2 138	–	**189 871**
Residential	90	–	35 459	1 218	–	–	490	42 100	65 149	63 018	**207 524**
Agriculture	–	–	27 495	576	–	–	490	4 700	3 042	406	**36 709**
Commerce and public services	–	–	15 250	1 230	–	–	80	2 600	52 682	37 973	**109 816**
Other consumption	–	–	20 217	–	–	–	–	–	6 642	–	**26 859**
Non-energy use	–	–	11 704	1 692	–	–	–	–	–	–	**13 396**

Comparison to CRF categories: Data from energy balance	Coal	Oil products	Natural gas	Peat	Wood and recy fuels	TOTAL excluding biomass	includi biomass	CRF 2002/EU sector to excl. biomass	Differenc
Transformation (CRF 1A1)	156 398	30 061	86 904	69 820	75 760	**343 183**	418 943	**355 158**	-3,4 %
Industry (CRF 1A2)	31 895	60 957	62 028	17 660	168 919	**172 540**	341 459	**171 067**	0,9 %
Transport (CRF 1A3)	–	186 833	900	–	–	**187 733**	187 733	**175 483**	7,0 %
Commerce and public services (CRF 1A4a)	–	15 250	1 230	80	2 600	**16 560**	19 160	**18 295**	-9,5 %
Residential (CRF 1A4b)	90	35 459	1 218	490	42 100	**37 257**	79 357	**36 620**	1,7 %
Agriculture (CRF 1A4c)	–	27 495	576	490	4 700	**28 561**	33 261	**28 072**	1,7 %
Other (CRF 1A5)	–	20 217	–	–	–	**20 217**	20 217	**17 805**	13,5 %
Totals by fuel	**188 383**	**376 271**	**152 856**	**88 540**	**294 079**	**806 050**	1 100 129	**802 500**	0,4%
Aviation bunkers correction **Totals**	 **188 383**	**-14 721** **361 550**	 **152 856**	 **88 540**	 **294 079**	 **791 329**	 **1 085 408**		
	Solid fuels	**Liquid fuels**	**Gaseous fu-els**	**Other**	**Bion**				
CRF totals by fuel	**184 758**	**368 015**	**154 676**	**95 051**	**281 491**	**802 500**	**1 083 991**		
difference	2,0 %	-1,8 %	-1,2 %	-6,9 %	4,5 %	-1,4 %	0,1 %		

Energy balance sheet 2002 (Gg CO_2)

	Coal	Crude oil & NGL	Petroleum products	Natural gas	Nuclear energy	Hydro & wind power	Peat fuel	Wood and recycled fuels	Electricity	District heat & heat pumps	TOTAL (fossil & peat)	TOTAL (incl. bio-mass)
Indigenous production	–	–	–	–	0	0	11 054	30 862	–	0	**11 054**	**41 916**
Imports	15 430	36 268	10 951	8 631	–	–	–	1 215	0	–	**71 280**	**72 496**
Exports	-4	–	-16 334	–	–	–	-38	–	0	–	**-16 376**	**-16 376**
International marine bunkers	–	–	-1 952	–	–	–	–	–	–	–	**-1 952**	**-1 952**
Stock Changes	2 039	518	383	–	–	–	-1 725	–	–	–	**1 215**	**1 215**
Total Primary Energy Supply	**17 465**	**36 786**	**-6 952**	**8 631**	**0**	**0**	**9 291**	**32 077**	**0**	**0**	**65 221**	**97 298**
Statistical Difference	–	–	-183	-16	–	–	–	–	–	–	**-199**	**-199**
Electricity generation	7 466	–	167	341	0	0	3 027	976	0	–	**11 002**	**11 978**
Combined district heat and power	4 556	–	250	3 530	–	–	3 594	1 805	0	0	**11 930**	**13 735**
Cogeneration electricity in industry	177	–	355	518	–	–	354	4 377	0	–	**1 405**	**5 782**
District heat production	236	–	673	461	–	–	352	1 061	–	0	**1 721**	**2 783**
Oil refinery	–	37 424	-36 111	–	–	–	–	–	–	–	**1 313**	**1 313**
Coal transformation	2 065	–	–	–	–	–	–	–	–	–	**2 065**	**2 065**
Transmission and distributions losses	–	–	–	–	–	–	–	–	0	0	**0**	**0**
TFC (total final energy)	**2 965**	**–**	**25 165**	**3 681**	**–**	**–**	**1 965**	**23 688**	**0**	**0**	**33 776**	**57 464**
Industry	2 957	–	4 431	3 462	–	–	1 853	18 328	0	0	**12 703**	**31 032**
Transport	–	–	13 580	50	–	–	–	–	–	–	**13 630**	**13 630**
Residential	8	–	2 577	68	–	–	51	4 568	0	0	**2 705**	**7 273**
Agriculture	–	–	1 998	32	–	–	51	510	0	0	**2 082**	**2 592**
Commerce and public services	–	–	1 108	69	–	–	8	282	0	0	**1 186**	**1 468**
Other consumption	–	–	1 470	–	–	–	–	–	0	–	**1 470**	**1 470**
Non-energy use	–	–	851	94	–	–	–	–	–	–	**945**	**945**
Total CO2 emissions (excluding non-energy use)	17 465		27 922	8 532			9 291	31 909			63 211	95 120
CO2 emission factor g/MJ	94,6	74,6	73,4	56,1	0,0	0,0	106,0	109,6	0,0	0,0		
oxidation factor	0,98	0,99	0,99	0,995	0,00	0,00	0,99	0,99	0,00	0,00		

Comparison to CRF categories: Data from energy balance	Coal	Petroleum products	Natural gas	Peat fuel	Wood and recycled fuels	TOTAL excluding biomass	including biomass	CRF 2001 sector totals excl. biomass	Difference
Transformation (CRF 1A1)	14 499	2 758	4 851	7 327	8 220	**29 435**	37 655	**28 947**	1,7 %
Industry (CRF 1A2)	2 957	4 431	3 462	1 853	18 328	**12 703**	31 032	**13 228**	-4,0 %
Transport (CRF 1A3)	–	13 580	50	–	–	**13 630**	13 630	**12 784**	6,6 %
Commerce and public services (CRF 1A4a)	–	1 108	69	8	282	**1 186**	1 468	**1 318**	-10,0 %
Residential (CRF 1A4b)	8	2 577	68	51	4 568	**2 705**	7 273	**2 686**	0,7 %
Agriculture (CRF 1A4c)	–	1 998	32	51	510	**2 082**	2 592	**2 074**	0,4 %
Other (CRF 1A5)	–	1 470	–	–	–	**1 470**	1 470	**1 174**	25,2 %
Totals by fuel	**17 465**	**27 922**	**8 532**	**9 291**	**31 909**	**63 211**	**95 120**	62 211	1,6 %
Aviation bunkers correction		**-1 042**							
Totals	**17 465**	**26 880**	**8 532**	**9 291**	**31 909**	**62 169**	**94 078**		
CRF totals by fuel	**17 280**	**26 891**	**8 573**	**9 467**	**30 513**	**62 211**	**92 725**		
difference	1,1 %	0,0 %	-0,5 %	-1,9 %	4,6 %	-0,1 %	1,5 %		

Annex 2. Emission factors implied in the energy sector

A. Emission factors of stationary sources in the ILMARI calculation system

Combustion technique code		Main category / main fuel code		CH_4 kg/TJ	N_2O kg/TJ
8	CFB	10	Coal fired boiler(> 80% coal)	4–5	70
		40	Peat fired boiler (> 80% peat)	2–7	30
		84	Multi-fuel/peat fired boiler (> 50% peat)	5	30
		50	Wood/bark fired boiler (> 80% wood)	30	10
		85	Multi-fuel/wood/bark fired boiler (> 50% wood)	4–35	10
		88	Multi-fuel fired boiler	30	30
7	BFB	10	Coal fired boiler(> 80% coal)	5	70
		40	Peat fired boiler (> 80% peat)	2–7	2
		84	Multi-fuel/peat fired boiler (> 50% peat)	2–5	2
		50	Wood/bark fired boiler (> 80% wood)	30	2
		85	Multi-fuel/wood/bark fired boiler (> 50% wood)	4–35	2
		88	Multi-fuel fired boiler	15	2
14	PFB	81	Multi-fuel/coal fired boiler (> 50% coal)	4	2
3	Stoker, grate	10	Coal fired boiler(> 80% coal)	4–8	4
		40	Peat fired boiler (> 80% peat)	2–7	2
		84	Multi-fuel/peat fired boiler (> 50% peat)	2–15	2
		50	Wood/bark fired boiler (> 80% wood)	30–50	2
		85	Multi-fuel/wood/bark fired boiler (> 50% wood)	20–35	2
		88	Multi-fuel fired boiler	10–35	2
1, 4, 5	Burners	10	Coal fired boiler(> 80% coal)	4	2
		30	Oil fired boiler(> 80% oil)	8	2
		40	Peat fired boiler (> 80% peat)	2–7	2
		50	Wood/bark fired boiler (> 80% wood)	50	2
		60	Gas fired boiler (> 80% gas)	3	1
		70	Soda recovery boiler (> 80% black liquor)	1	1
		81–88	Multi-fuel fired boiler	2–50	1–2
10	Gas turbine	121	Gas turbine plant (oil)	8	1
		122	Gas turbine plant (gas)	3	1
10x12	Gas turbine (Combined cycle)	130	Gas turbine /Combined cycle	3	1
11	Diesel engine	141	Diesel power plant (oil)	2	31
11	Diesel engine	142	Diesel power plant (gas)	2	31
115	Internal combustion engine (Otto)	143	Other combustion engine power plant	2	31
	Other combustion (not specified)	90, 150	Not specified	8–10	2
		91	Mesa kiln	8	2
		92	Hospital waste incineration	8–50	2
		93	Asphalt station	8	2
		94	Coking plant	0	2
		95	Drying oven	8	2
		96	Blast furnace	0	2
		97	Sinter plant	4	2
		98	Rolling mill	0	2
		99	Melting oven	0	2
		100	Brick furnace	8	2
		101	Cupola oven	8–10	2

B. Emission factors of small combustion in ILMARI calculation system

Small combustion boilers < 1 MW	CH_4 kg/TJ	N_2O kg/TJ	CO kg/TJ	NMVOC kg/TJ
Oil	10	2	20	5
Coal	300	4	200	200
Natural gas	3	1	50	5
Peat	50	4	200	200
Wood	300	4	2 100	600
References:	IPCC Table 1–7 Boström (1994)	IPCC Table 1–8 Boström (1994)	IPCC Table 1–10 Boström (1994)	IPCC Table 1–11 Peat: the same EF as for Coal

C. Emission factors of transport sectors and off-road machinery in ILMARI calculation system

CRF	Sector	Fuel	Detailed calculation model	CH_4 kg/TJ	N_2O kg/TJ	CO kg/TJ	NMVOC kg/TJ
CRF 1.A.3a	Domestic aviation	Aviation gasoline	ILMI	30.6	3.0	23 600	275
CRF 1.A.3a	Domestic aviation	Jet fuel	ILMI	2.7	3.0	112	24
CRF 1.A.3b	Road transport	Diesel oil	LIISA	3.7	2.2	247	72
CRF 1.A.3b	Road transport	Gasoline	LIISA	30.1	11.1	4 207	447
CRF 1.A.3b	Road transport	Natural gas	LIISA	610.0	1.1	730	110
CRF 1.A.3c	Railways	Gasoil (diesel)	RAILI	4.0	30.0	233	94
CRF 1.A.3d	Domestic navigation / Passengers & cargo	Gasoil (diesel)	MEERI	3.7	30.0	180	58
CRF 1.A.3d	Domestic navigation / Passengers & cargo	Residual fuel oil	MEERI	5.0	2.0	81	37
CRF 1.A.3d	Domestic navigation / Leisure boats	Gasoline	MEERI	199.0	2.0	11 368	3 781
CRF 1.A.3d	Domestic navigation / Leisure boats	Gasoil (diesel)	MEERI	8.2	30.0	377	129
CRF 1.A.4c	Fishing vessels	Gasoil (diesel)	MEERI	4.1	30.0	212	64
CRF 1.A.3d	Domestic navigation/Other	Gasoil (diesel)	MEERI	3.7	30.0	180	58
CRF IntBunk	International aviation	Jet fuel	ILMARI	2.7	3.0	112	24
CRF IntBunk	International navigation	Gasoil (diesel)	ILMARI	3.7	30.0	180	58
CRF IntBunk	International navigation	Residual fuel oil	ILMARI	5.0	2.0	81	37
CRF 1.A.4c	Off-road machinery / Agriculture	Gasoil (diesel)	TYKO	4.0	31.8	390	153
CRF 1.A.4c	Off-road machinery / Agriculture	Gasoline	TYKO	129.8	1.6	29 100	1 520
CRF 1.A.4c	Off-road machinery / Forestry	Gasoline	TYKO	139.0	0.3	27 482	9 364
CRF 1.A.4c	Off-road machinery / Forestry	Gasoil (diesel)	TYKO	4.3	32.5	379	119
CRF 1.A.2f	Off-road machinery / Construction	Gasoil (diesel)	TYKO	4.3	31.7	383	153
CRF 1.A.2f	Off-road machinery / Construction	Gasoline	TYKO	133.4	1.7	27 897	1 438
CRF 1.A.3e	Off-road machinery / Other	Gasoline	TYKO	95.0	1.2	18 712	1 963
CRF 1.A.3e	Off-road machinery / Other	LPG	TYKO	64.6	3.2	2 661	99
CRF 1.A.3e	Off-road machinery / Other	Gasoil (diesel)	TYKO	4.1	31.5	387	149

D. CO_2 emission factors

	g CO_2/MJ	kg C/GJ	Ref.	Oxidation factor	NCV		Notes
Gasoline	72.7	19.8	2	1	43.0	GJ/t	
Diesel oil	73.0	19.9	2	1	42.8	GJ/t	
Light fuel oil (gasoil)	74.1	20.2	1	0.99	42.4	GJ/t	
Residual fuel oil	77.4	21.1	1	0.99	40.7	GJ/t	40.5–41.1 GJ/t
Jet fuel	71.5	19.5	1	0.99	42.3	GJ/t	
Kerosene	71.5	19.5	?	0.99	43.4	GJ/t	
Naphta	72.7	19.8	1	0.99	44.3	GJ/t	
LPG	63.1	17.2	1	0.99	45.7	GJ/t	
Waste oil	77.4	21.1	4	0.99	40.9	GJ/t	
Refinery gas	65.0	17.7	7	0.99	47.5	GJ/1 000 m^3	
Refinery coke	97.0	26.5	7	0.99	33.3	GJ/t	
Hard coal	94.6	25.8	1	0.99	25.5	GJ/t	
Coke	108.0	29.5	1	0.98	29.3	GJ/t	
Anthracite and briquettes	94.6	25.8	1	0.98	33.5	GJ/t	
Blast furnace gas	0.0	0.0	9		3.8	GJ/1 000 m^3	
Coke oven gas	40.5	11.0	7	0.98	16.7	GJ/1 000 m^3	
Natural gas	56.1	15.3	1	0.995	36.0	GJ/1 000 m^3	
Peat	106.0	28.9	1	0.99	10.1 –12.3	GJ/t	
Fuelwood	109.6	29.9	1	0.99			varying NCVs
Bark	109.6	29.9	1	0.99			varying NCVs
Wood chips	109.6	29.9	1	0.99			varying NCVs
Sawdust	109.6	29.9	1	0.99			varying NCVs
Other residues from wood proc. industry	109.6	29.9	5	0.99			varying NCVs
Black liquor	110.0	30.0	3	0.99	12.6	GJ/tdm	
Sulphite liquor	112.0	30.5	3	0.99	9.9	GJ/tdm	
Malodorous gases from wood proc. industry	59.0	16.1		0.99	44.9		
0-fibres / biosludge	109.6	29.9	5	0.99	5.4	GJ/t	
Waste paper	109.6	29.9	5	0.99	14.0	GJ/t	
Municipal waste	31.8	8.7	10	0.99	10–21	GJ/t	share of fossil carbon
Construction & demolition waste	31.8	8.7	10	0.99	10.0	GJ/t	share of fossil carbon
Industrial waste	75.0	20.5	8	0.99	42.9	GJ/t	
Plastic waste	74.1	20.2	6	0.99	40.0	GJ/t	
Other wastes	75.0	20.5	8	0.99	8.8	GJ/t	
Other fuels			6	0.99	5–40	GJ/t	74–150 g CO_2/MJ

References

1	IPCC Guidelines 1995	6	Depends on type of fuel; assumed same as for corresponding fuels
2	VTT, LIISA model	7	Plant specific data
3	Boström et al. 1992	8	Ref. not specified (expert guess)
4	Assumed same as for residual fuel oil	9	Assumed zero to avoid double-counting (CO_2 emissions from blast furnaces included in coke and RFO used in these plants)
5	Assumed same as for fuelwood	10	Expert estimate by VTT and Statistics Finland

E. Comments to emission factors in ILMARI calculation system

In the ILMARI system emissions are calculated by a bottom-up method using annual fuel consumption for boilers and processes. ILMARI includes also technical data of boilers, such as combustion technique, fuel capacity, emission reduction equipment etc. The CH_4, N_2O, CO and NMVOC emission factors used in the Finnish inventory are largely based on the compilation of research data by Prosessikemia Oy (Boström et al. 1992; Boström 1994) in the inventory calculations for the year 1990 for Finland's first national communication to the UNFCCC.

The emission factor database from Prosessikemia Oy has been expanded to fit ILMARI's more detailed classification of boilers and processes. As new boiler types have been included in the boiler database, the emission factors have been determined on basis of expert opinion (when no data has been available from other sources). In the future, emission factors have to be checked against the Revised 1996 IPCC Guidelines and new data from national research.

Emission factors for small combustion are partly IPCC default and partly taken from the reference Boström et.al. (1992).

In the transport sectors the emission factors used in the ILMARI system are taken as average emission factors from the calculation models of the VTT. Emission factors for international bunker emissions are the same as for corresponding domestic transport sectors.

CH_4 and N_2O emissions from railway, navigation and aviation have been calculated with the ILMARI system from aggregated fuel data, using selected emission factors from the IPCC tables.

Annex 3. Additional information on uncertainty reporting

TABLE A. Tier 2 uncertainty reporting

A	B	C	D	E	F	G	H	I	J
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Gas**	**Base year (1990) emissions**	**Year t (2002) emissions**	**Uncertainty in year 2002 emissions as % of emissions in the category**		**uncertainty introduced on national total in year 2002**	**% change in emissions between year t and base year**	**range of likely % change between year t and base year**	
		Gg CO2 equivalent	**Gg CO2 equivalent**	**% below (2.5 percentile)**	**% above (97.5 percentile)**	**%**	**%**	**Lower % (2.5 percentile)**	**Upper % (97.5 percentile)**
1.A. Fuel Combustion									
Liquid Fuels	CO2	27 386	26 747	3	3	0.96	-2	-5	1
Solid fuels	CO2	15 746	17 273	3	3	0.73	10	7	12
Gaseous fuels	CO2	5 087	8 573	1	1	0.15	69	66	71
Other fuels	CO2	5 674	9 388	6	7	0.77	65	56	75
1.A.1 Energy Industries									
Liquid Fuels	CH4	6	7	75	12	0.01	18	-23	78
	N2O	26	29	75	12	0.03	13	-26	71
Solid Fuels	CH4	9	11	75	12	0.01	33	-13	110
	N2O	85	122	50	50	0.08	45	17	78
Gaseous Fuels	CH4	4	7	75	11	0.01	98	28	216
	N2O	18	36	50	50	0.02	104	65	151
Biomass	CH4	2	27	51	56	0.02	1 186	798	1 749
	N2O	10	83	71	153	0.16	761	429	1 305
Other Fuels	CH4	5	6	50	50	0.00	12	-11	40
	N2O	141	207	70	148	0.39	47	-4	123
1.A.2. Manufacturing Industries and Construction									
Liquid Fuels	CH4	8	7	74	12	0.01	-10	-45	47
	N2O	83	152	75	12	0.14	84	10	197
Solid Fuels	CH4	4	3	76	12	0.00	-36	-62	6
	N2O	108	89	50	50	0.06	-17	-35	4
Gaseous Fuels	CH4	5	6	75	11	0.01	35	-19	132
	N2O	17	20	50	50	0.01	16	-8	48
Biomass	CH4	20	19	51	54	0.01	-5	-31	32
	N2O	111	83	71	151	0.16	-26	-55	23
Other Fuels	CH4	4	3	51	51	0.00	-29	-45	-8
	N2O	56	25	70	149	0.05	-56	-73	-29

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas	Base year (1990) emissions	Year t (2002) emissions	Uncertainty in year 2002 emissions as % of emissions in the category		uncertainty introduced on national total in year 2002	% change in emissions between year t and base year	range of likely % change between year t and base year	
		Gg CO2 equivalent	Gg CO2 equivalent	% below (2.5 percentile)	% above (97.5 percentile)	%	%	Lower % (2.5 percentile)	Upper % (97.5 percentile)
1.A.3. Transport									
a. Civil Aviation	CH4	11	0.3	57	100	0.00	-98	-98	-97
	N2O	57	4	70	149	0.01	-93	-96	-89
b. Road Transportation									
Gasoline	CH4	44	43	50	50	0.03	-2	-25	26
Cars with Catalytic Converters	N2O	35	380	94	378	1.80	974	291	2 805
Cars without Catalytic Converters	N2O	67	20	86	258	0.06	-70	-88	-28
Diesel	CH4	15	6	50	50	0.00	-61	-70	-50
	N2O	80	81	99	158	0.16	2	-87	249
Natural gas	CH4	0	1	50	50	0.00	*	*	*
	N2O	0	0.04	70	149	0.00	*	*	*
c. Railways	CH4	0.1	0.1	60	109	0.00	40	-5	106
	N2O	25	17	70	150	0.03	-33	-60	11
d. Navigation									
Residual Oil & Gas/Diesel Oil	CH4	0.1	0.5	57	101	0.00	300	171	493
	N2O	29	25	70	151	0.05	-15	-50	45
Gasoline	CH4	0	9	59	104	0.01	*	*	*
	N2O	0	0	71	150	0.00	*	*	*
e. Other Transportation									
Liquid fuels	CH4	0.3	7	54	64	0.01	2 227	1 289	3 840
Gasoline	N2O	1	0.7	72	158	0.00	-18	-59	63
Diesel	N2O	75	61	90	71	0.07	-18	-77	73
1.A.4. Other Sectors									
Liquid Fuels	CH4	19	16	75	13	0.02	-17	-56	53
	N2O	201	183	74	13	0.17	-9	-51	73
Solid Fuels	CH4	0.1	0.6	74	20	0.00	460	204	960
	N2O	0.3	0.3	50	52	0.00	0	-27	37
Gaseous Fuels	CH4	0.1	0.3	75	15	0.00	100	8	281
	N2O	1	1	50	50	0.00	100	47	172
Biomass	CH4	245	311	70	149	0.58	27	-30	129
	N2O	24	61	71	152	0.12	151	38	354
Other Fuels	CH4	5	1	53	60	0.00	-76	-85	-62
	N2O	1	1	71	154	0.00	0	-49	94

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas	Base year (1990) emissions	Year t (2002) emissions	Uncertainty in year 2002 emissions as % of emissions in the category		uncertainty introduced on national total in year 2002	% change in emissions between year t and base year	range of likely % change between year t and base year	
		Gg CO2 equivalent	Gg CO2 equivalent	% below (2.5 percentile)	% above (97.5 percentile)	%	%	Lower % (2.5 percentile)	Upper % (97.5 percentile)
1.A.5. Other									
Liquid Fuels	CH4	2	2	76	17	0.00	-13	-55	71
	N2O	6	11	75	17	0.01	85	-6	269
Gaseous Fuels	CH4	0.3	0.4	75	22	0.00	43	-27	186
	N2O	1	2	51	53	0.00	75	23	149
1.B. Fugitive Emissions from Fuels									
1.B.1 Solid Fuels									
Arable peatlands	CO2	2 500	2 500	69	131	4.12	0	0	0
Peat production areas	CO2	1 000	1 000	80	205	2.58	0	0	0
	CH4	21	21	80	208	0.05	0	0	0
1.B.2. Oil and Natural Gas	CO2	42	23	22	23	0.01	-46	-55	-35
	CH4	4	8	22	23	0.00	111	76	153
2. Industrial Processes									
2.A.1 Cement Production	CO2	777	565	7	7	0.05	-27	-33	-22
2.A.2 Lime Production	CO2	398	425	11	11	0.06	7	-8	23
2.B.2 Nitric Acid Production	N2O	1 594	1 311	57	100	1.65	-18	-47	28
2.B.5 Other	CH4	4	5	21	21	0.00	21	6	39
2.C Iron and Steel production	CH4	5	10	20	20	0.00	87	65	113
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs, PFCs	0	385	8	24	0.12	*	*	*
2.F.2 Foam Blowing	HFCs	0	23	29	28	0.01	*	*	*
2.F.4 Aerosols	HFCs	0	67	2	2	0.00	*	*	*
2.F.7 Electrical Equipment	SF6	87	33	8	13	0.01	-61	-75	-22
2.F Other (grouped data)	HFCs, PFCs, SF6	8	19	36	36	0.01	139	31	408
3. Total Solvent and Other Product Use	N2O	62	44	34	38	0.02	-30	-55	11
4. Agriculture									
4.A. Enteric fermentation	CH4	1 868	1 562	29	30	0.58	-16	-31	1
4.B. Manure management	CH4	199	202	17	17	0.04	2	-9	14
4.B. Manure management	N2O	554	378	82	33	0.39	-32	-74	85
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N2O	3 506	2 720	56	56	1.90	-22	-52	25
4.D. Agricultural soils: indirect emissions	N2O	764	557	82	340	2.38	-27	-77	138

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas	Base year (1990) emissions	Year t (2002) emissions	Uncertainty in year 2002 emissions as % of emissions in the category		uncertainty introduced on national total in year 2002	% change in emissions between year t and base year	range of likely % change between year t and base year	
		Gg CO2 equivalent	Gg CO2 equivalent	% below (2.5 percentile)	% above (97.5 percentile)	%	%	Lower % (2.5 percentile)	Upper % (97.5 percentile)
6. Waste									
6.A. Solid Waste Disposal on Land	CH4	3 679	2 684	43	43	1.46	-27	-62	32
6.B.1 Industrial Wastewater	CH4	22	19	61	110	0.03	-16	-33	7
6.B.2 Domestic and Commercial Wastewater									
sparsely pop areas	CH4	118	96	34	27	0.04	-19	-49	31
densely pop areas	CH4	12	13	60	108	0.02	6	-11	26
sparsely pop areas	N2O	21	18	94	381	0.08	-16	-35	5
densely pop areas	N2O	84	65	94	383	0.31	-23	-40	-2
6.B.3. N input from Fish Farming	N2O	8	4	94	375	0.02	-58	-69	-42
6.B.3. N input from industrial wastewater	N2O	28	17	94	374	0.08	-38	-55	-16
7.Other - non-energy use of fuels	CO2	640	720	50	50	0.45	12	-49	151
Total		73 564	79 662	5	6		8	4	13

*Trend not calculated, when base year emissions ≈ 0.

TABLE B. Tier 1 uncertainty reporting, columns A-M.

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Greenhouse Gas Source and Sink Categories	**Direct Green house Gas**	**Base Year emissions, 1990**	**Current Year emissions, 2002**	**Activity data uncertainty**	**Emission factor uncertainty[1]**	**Combined uncertainty**	**Combined uc as part of total national emissions in 2002**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
1.A. Fuel Combustion Activities												
Liquid Fuels	CO_2	27 386	26 747	2 %	2 %	2.83 %	0.95 %	-0.0394	0.3636	-0.08 %	1.03 %	1.03 %
Solid fuels	CO_2	15 746	17 273	2 %	3 %	3.35 %	0.73 %	0.0030	0.2348	0.01 %	0.50 %	0.50 %
Gaseous fuels	CO_2	5 087	8 573	1 %	1 %	1.41 %	0.15 %	0.0416	0.1165	0.04 %	0.16 %	0.17 %
Other fuels	CO_2	5 674	9 388	4 %	5 %	6.40 %	0.75 %	0.0440	0.1276	0.22 %	0.72 %	0.75 %
1.A.1 Energy Industries												
Liquid Fuels	CH_4	6	7	2 %	75 %	75 %	0.01 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
	N_2O	26	29	2 %	75 %	75 %	0.03 %	0.0000	0.0004	0.00 %	0.00 %	0.00 %
Solid fuels	CH_4	9	11	2 %	75 %	75 %	0.01 %	0.0000	0.0002	0.00 %	0.00 %	0.00 %
	N_2O	85	122	2 %	50 %	50 %	0.08 %	0.0004	0.0017	0.02 %	0.00 %	0.02 %
Gaseous fuels	CH_4	4	7	1 %	75 %	75 %	0.01 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
	N_2O	18	36	1 %	50 %	50 %	0.02 %	0.0002	0.0005	0.01 %	0.00 %	0.01 %
Biomass	CH_4	2	27	20 %	50 %	54 %	0.02 %	0.0003	0.0004	0.02 %	0.01 %	0.02 %
	N_2O	10	83	20 %	150 %	151 %	0.16 %	0.0010	0.0011	0.15 %	0.03 %	0.15 %
Other fuels	CH_4	5	6	5 %	50 %	50 %	0.00 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
	N_2O	141	207	5 %	150 %	150 %	0.39 %	0.0007	0.0028	0.11 %	0.02 %	0.11 %
1.A.2. Manufacturing Industries and Construction												
Liquid Fuels	CH_4	8	7	2 %	75 %	75 %	0.01 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
	N_2O	83	152	2 %	75 %	75 %	0.14 %	0.0008	0.0021	0.06 %	0.01 %	0.06 %
Solid fuels	CH_4	4	3	2 %	75 %	75 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N_2O	108	89	2 %	50 %	50 %	0.06 %	-0.0004	0.0012	-0.02 %	0.00 %	0.02 %
Gaseous fuels	CH_4	5	6	1 %	75 %	75 %	0.01 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
	N_2O	17	20	1 %	50 %	50 %	0.01 %	0.0000	0.0003	0.00 %	0.00 %	0.00 %
Biomass	CH_4	20	19	15 %	50 %	52 %	0.01 %	0.0000	0.0003	0.00 %	0.01 %	0.01 %
	N_2O	111	83	15 %	150 %	151 %	0.16 %	-0.0005	0.0011	-0.08 %	0.02 %	0.08 %
Other fuels	CH_4	4	3	5 %	50 %	50 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N_2O	56	25	5 %	150 %	150 %	0.05 %	-0.0005	0.0003	-0.07 %	0.00 %	0.07 %

IPCC Greenhouse Gas Source and Sink Categories	**Direct Green house Gas**	**Base Year emissions, 1990**	**Current Year emissions, 2002**	**Activity data uncertainty**	**Emission factor uncertainty[1]**	**Combined uncertainty**	**Combined uc as part of total national emissions in 2002**	**Type A sensitivity**	**Type B sensitivity**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty**	**Uncertainty in trend in national emissions introduced by activity data uncertainty**	**Uncertainty introduced into the trend in total national emissions**
1.A.3. Transport												
a. Civil Aviation	CH4	11	0	5 %	100 %	100 %	0.00 %	-0.0002	0.0000	-0.02 %	0.00 %	0.02 %
	N2O	57	4	5 %	150 %	150 %	0.01 %	-0.0008	0.0001	-0.12 %	0.00 %	0.12 %
b. Road Transportation												
Gasoline	CH4	44	43	1 %	50 %	50 %	0.03 %	-0.0001	0.0006	0.00 %	0.00 %	0.00 %
Cars with Catalytic Converters	N2O	35	380	1 %	378 %	378 %	1.80 %	0.0046	0.0052	1.75 %	0.01 %	1.75 %
Cars without Catalytic Converters	N2O	67	20	1 %	259 %	259 %	0.06 %	-0.0007	0.0003	-0.19 %	0.00 %	0.19 %
Diesel	CH4	15	6	1 %	50 %	50 %	0.00 %	-0.0001	0.0001	-0.01 %	0.00 %	0.01 %
	N2O	80	81	1 %	158 %	158 %	0.16 %	-0.0001	0.0011	-0.01 %	0.00 %	0.01 %
Natural gas	CH4	0	1	1 %	50 %	50 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	0	0	1 %	150 %	150 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
c. Railways	CH4	0.1	0.1	5 %	110 %	110 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	25	17	5 %	150 %	150 %	0.03 %	-0.0001	0.0002	-0.02 %	0.00 %	0.02 %
d. Navigation												
Residual Oil & Gas/Diesel Oil	CH4	0.1	1	10 %	100 %	100 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	29	25	10 %	150 %	150 %	0.05 %	-0.0001	0.0003	-0.01 %	0.00 %	0.01 %
Gasoline	CH4	0	9	20 %	100 %	102 %	0.01 %	0.0001	0.0001	0.01 %	0.00 %	0.01 %
	N2O	0	0	20 %	150 %	151 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
e. Other Transportation												
Gasoline&Diesel	CH4	0.3	7	30 %	50 %	58 %	0.01 %	0.0001	0.0001	0.00 %	0.00 %	0.01 %
Gasoline	N2O	1	1	30 %	150 %	153 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
Diesel	N2O	75	61	30 %	90 %	95 %	0.07 %	-0.0003	0.0008	-0.02 %	0.04 %	0.04 %
1.A.4. Other Sectors												
Liquid Fuels	CH4	19	16	3 %	75 %	75 %	0.02 %	-0.0001	0.0002	0.00 %	0.00 %	0.01 %
	N2O	201	183	3 %	75 %	75 %	0.17 %	-0.0005	0.0025	-0.03 %	0.01 %	0.04 %
Solid fuels	CH4	0.1	1	10 %	75 %	76 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	0.3	0.3	10 %	50 %	51 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
Gaseous fuels	CH4	0.1	0.3	5 %	75 %	75 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %

IPCC Greenhouse Gas Source and Sink Categories	Direct Green house Gas	Base Year emissions, 1990	Current Year emissions, 2002	Activity data uncertainty	Emission factor uncertainty[1]	Combined uncertainty	Combined uc as part of total national emissions in 2002	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
	N2O	1	1	5 %	50 %	50 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
Biomass	CH4	245	311	15 %	150 %	151 %	0.59 %	0.0006	0.0042	0.09 %	0.09 %	0.13 %
	N2O	24	61	15 %	150 %	151 %	0.12 %	0.0005	0.0008	0.07 %	0.02 %	0.07 %
Other fuels	CH4	5	1	25 %	50 %	56 %	0.00 %	-0.0001	0.0000	0.00 %	0.00 %	0.00 %
	N2O	1	1	25 %	150 %	152 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
1.A.5. Other												
Liquid Fuels	CH4	2	2	7 %	75 %	75 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	6	11	7 %	75 %	75 %	0.01 %	0.0001	0.0002	0.00 %	0.00 %	0.01 %
Gaseous fuels	CH4	0.3	0.4	12 %	75 %	76 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
	N2O	1	2	12 %	50 %	51 %	0.00 %	0.0000	0.0000	0.00 %	0.00 %	0.00 %
1.B. Fugitive Emissions from Fuels												
1.B.1 Solid Fuels												
arable peatlands	CO2	2 500	2 500	109 %	50 %	120 %	3.77 %	-0.0028	0.0340	-0.14 %	-0.31 %	0.34 %
peat production areas	CO2	1 000	1 000	10 %	208 %	208 %	2.61 %	-0.0011	0.0136	-0.23 %	-0.01 %	0.23 %
	CH4	21	21	10 %	208 %	208 %	0.05 %	0.0000	0.0003	0.00 %	0.00 %	0.00 %
1.B.2. Oil and Natural Gas	CO2	42	23	10 %	20 %	22 %	0.01 %	-0.0003	0.0003	-0.01 %	0.00 %	0.01 %
	CH4	4	8	10 %	20 %	22 %	0.00 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
2. Industrial Processes												
2.A.1 Cement Production	CO2	777	565	5 %	5 %	7%	0.05 %	-0.0038	0.0077	-0.02 %	0.05 %	0.06 %
2.A.2 Lime Production	CO2	398	425	10 %	5 %	11 %	0.06 %	-0.0001	0.0058	0.00 %	0.08 %	0.08 %
2.B.2 Nitric Acid Production	N2O	1 594	1 311	5 %	100 %	100 %	1.65 %	-0.0056	0.0178	-0.56 %	0.13 %	0.58 %
2.B.5 Other	CH4	4	5	5 %	20 %	21 %	0.00 %	0.0000	0.0001	0.00 %	0.00 %	0.00 %
2.C Iron and Steel production	CH4	5	10	3 %	20 %	20 %	0.00 %	0.0001	0.0001	0.00 %	0.00 %	0.00 %
2.F.1. Refrigeration and Air Conditioning Equipment	HFC	0	385	24 %	0 %	24 %	0.12 %	0.0052	0.0052	0.00 %	0.18 %	0.18 %
2.F.2 Foam Blowing	HFC	0	23	29 %	0 %	29 %	0.01 %	0.0003	0.0003	0.00 %	0.01 %	0.01 %
2.F.4 Aerosols	HFC	0	67	2 %	0 %	2%	0.00 %	0.0009	0.0009	0.00 %	0.00 %	0.00 %
2.F.7 Electrical Equipment	SF6	87	33	14 %	0 %	14 %	0.01 %	-0.0008	0.0005	0.00 %	0.01 %	0.01 %

IPCC Greenhouse Gas Source and Sink Categories	Direct Green house Gas	Base Year emissions, 1990	Current Year emissions, 2002	Activity data uncertainty	Emission factor uncertainty[1]	Combined uncertainty	Combined uc as part of total national emissions in 2002	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
2.F Other (grouped data)	HFC PFC SF6	8	19	36 %	0 %	36 %	0.01 %	0.0001	0.0003	0.00 %	0.01 %	0.01 %
3. Total Solvent and Other Product Use	N2O	62	44	30 %	20 %	36 %	0.02 %	-0.0003	0.0006	-0.01 %	0.03 %	0.03 %
4. Agriculture												
4.A.Enteric fermentation	CH4	1 868	1 562	29.58 %	0.00 %	30 %	0.58 %	-0.0063	0.0212	0.00 %	0.89 %	0.89 %
4.B.Manure management	CH4	199	202	17.07 %	0.00 %	17 %	0.04 %	-0.0002	0.0027	0.00 %	0.07 %	0.07 %
4.B.Manure management	N2O	554	378	82.34 %	0.00 %	82 %	0.39 %	-0.0030	0.0051	0.00 %	0.60 %	0.60 %
4.D.Agricultural soils: direct emissions, animal production and sludge spreading	N2O	3 506	2 720	55.75 %	0.00 %	56 %	1.90 %	-0.0146	0.0370	0.00 %	2.91 %	2.91 %
4.D.Agricultural soils: indirect emissions	N2O	764	557	339.86 %	100.00 %	354 %	2.48 %	-0.0037	0.0076	-0.37 %	3.64 %	3.66 %
6. Waste												
6.A. Solid Waste disposal on Land	CH4	3 679	2 684	43 %	0 %	43 %	1.45 %	-0.0177	0.0365	0.00 %	2.22 %	2.22 %
6.B.1 Industrial Wastewater	CH4	22	19	10 %	104 %	105 %	0.02 %	-0.0001	0.0003	-0.01 %	0.00 %	0.01 %
6.B.2 Domestic and Commercial Wastewater												
sparcely populated areas	CH4	118	96	15 %	32 %	35 %	0.04 %	-0.0004	0.0013	-0.01 %	0.03 %	0.03 %
densely populated areas	CH4	12	13	5 %	104 %	105 %	0.02 %	0.0000	0.0002	0.00 %	0.00 %	0.00 %
sparcely populated areas	N2O	21	18	10 %	380 %	380 %	0.08 %	-0.0001	0.0002	-0.03 %	0.00 %	0.03 %
densely populated areas	N2O	84	65	5 %	380 %	380 %	0.31 %	-0.0004	0.0009	-0.14 %	0.01 %	0.14 %
6.B.3. N input from Fish Farming	N2O	8	4	10 %	380 %	380 %	0.02 %	-0.0001	0.0000	-0.03 %	0.00 %	0.03 %
6.B.3. N input from industrial wastewater	N2O	28	17	5 %	380 %	380 %	0.08 %	-0.0002	0.0002	-0.07 %	0.00 %	0.07 %
7.Other - non-energy use of fuels	CO2	640	720	50 %	5 %	50 %	0.45 %	0.0004	0.0098	0.00 %	0.69 %	0.69 %
Total		73 564	79 662				6.51 %					5.84 %

[1]When uncertainties are calculated with a separate model, resulting uncertainty in emissions is reported in column E, thus resulting in 0% in column F.

TABLE C. Tier 1 uncertainty reporting, columns A-B and N-Q.

A	B	N	O	P	Q
IPCC Greenhouse Gas Source and Sink Categories	**Direct Greenhouse Gas**	**Emission factor quality indicator**	**Activity data quality indicator**	**Expert judgement reference numbers[1]**	**Footnote Reference numbers[1]**
1.A. Fuel Combustion					
Liquid fuels	CO2	R	R	E1	
Solid fuels	CO2	R	R	E1	
Gaseous fuels	CO2	R	R	E1	
Other fuels	CO2	R	R	E1	M4
1.A.1 Energy Industries					
Liquid Fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	M2
Solid fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
Gaseous fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
Biomass	CH4	R	R	E1	
	N2O	R	R	E1	
Other fuels	CH4	R	R	E1	
	N2O	R	R	E1	
1.A.2. Manufacturing Industries and Construction					
Liquid Fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	M2
Solid fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
Gaseous fuels	CH4	R	R	E1	
	N2O	R	R	E1	
Biomass	CH4	R	R	E1	
	N2O	R	R	E1	
Other fuels	CH4	R	R	E1	
	N2O	R	R	E1	
1.A.3. Transport					
a. Civil Aviation	CH4	D	R		L4
	N2O	R	R		
b. Road Transportation					
Gasoline	CH4	M	R		L5
Cars with Catalytic Converters	N2O	M	R		L6,L7,L8,L9,L10,L19,L20, L21,L22,L23
Cars without Catalytic Converters	N2O	M	R		L6, L9, L10, L19, L21
Diesel	CH4	M	R		L5
	N2O	M	R		L6, L8, L11, L21
Natural gas	CH4	M	R		L5
	N2O	R	R		
c. Railways	CH4	M	R		M3
	N2O	R	R		M3
d. Navigation					
Residual Oil & Gas/Diesel Oil	CH4	D	R		L4
	N2O	R	R		
Gasoline	CH4	R	R		L4
	N2O	R	R		
e. Other Transportation					
Gasoline&Diesel	CH4	R	R		
Gasoline	N2O	R	R		
Diesel	N2O	R	R		

IPCC Greenhouse Gas Source and Sink Categories	Direct Greenhouse Gas	Emission factor quality indicator	Activity data quality indicator	Expert judgement reference numbers[1]	Footnote Reference numbers[1]
1.A.4. Other Sectors					
Liquid Fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	M2
Solid fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
Gaseous fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
Biomass	CH4	R	R	E1	
	N2O	R	R	E1	
Other fuels	CH4	R	R	E1	
	N2O	R	R	E1	
1.A.5. Other					
Liquid Fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	M2
Gaseous fuels	CH4	R	R	E1	M2
	N2O	R	R	E1	
1.B. Fugitive Emissions from Fuels					
1.B.1 Solid Fuels					
arable peatlands	CO2	R	R		L3
peat production areas	CO2	R	R		
	CH4	R	R		
1.B.2. Oil and Natural Gas	CO2	R	R	E1	
	CH4	R	R	E1	
2. Industrial Processes					
2.A.1 Cement Production	CO2	R	R	E1	
2.A.2 Lime Production	CO2	R	R	E1	
2.B.2 Nitric Acid Production	N2O	R	R		M1
2.B.5 Other	CH4	R	R	E1	
2.C Iron and Steel production	CH4	R	R	E1	
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs	R	R		L24
2.F.2 Foam Blowing	HFCs	R	R		L24
2.F.4 Aerosols	HFCs	R	R		L24
2.F.7 Electrical Equipment	SF6	R	R		L24
2.F Other (grouped data)	HFCs, PFCs, SF6	R	R		L24
3. Total Solvent and Other Product Use	N2O	R	R	E1	
4. Agriculture					
4.A.Enteric fermentation	CH4	D/R	R		L4, L13
4.B.Manure management	CH4	R	R		
4.B.Manure management	N2O	R	R		L12, L14, L15, L16, L17, L4
4.D.Agricultural soils: direct emissions, animal production and sludge spreading	N2O	D/R	R		L2, L18
4.D.Agricultural soils: indirect emissions	N2O	D/R	R		L2, L18

IPCC Greenhouse Gas Source and Sink Categories	Direct Greenhouse Gas	Emission factor quality indicator	Activity data quality indicator	Expert judgement reference numbers[1]	Footnote Reference numbers[1]
6. Waste					
6.A. Solid Waste disposal on Land	CH4	R	R	E2	L4
6.B.1 Industrial Wastewater	CH4	R	R	E2	L4
6.B.2 Domestic and Commercial Wastewater					
sparcely populated areas	CH4	R	R	E3	
densely populated areas	CH4	R	R	E2	L4
sparcely populated areas	N2O	R	R	E2	L2
densely populated areas	N2O	R	R	E2	L2
6.B.3. N input from Fish Farming	N2O	R	R	E2	L2
6.B.3. N input from industrial wastewater	N2O	R	R	E2	L2
7.Other - non-energy use of fuels	CO2	R	R	E1	

[1] See Table D.

TABLE D. References of Table C: Bases for uncertainty estimates.

Expert Elicitations	
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E2	Jouko Petäjä (Finnish Environment Institute) 21 November 2002
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TABLE E. Source Category Analysis Summary for 2002.

Quantitative Method Used: Tier 2			
A	B	C	D
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category**	**Criteria of identification[1]**
1.A. Fuel Combustion			
Liquid fuels	CO2	YES	L, T
Solid fuels	CO2	YES	L
Gaseous fuels	CO2	NO	
Other fuels	CO2	YES	L, T
1.A.1 Energy Industries			
Liquid fuels	CH4	NO	
	N2O	NO	
Solid fuels	CH4 N2O	NO NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	NO	
	N2O	YES	T
Other fuels	CH4	NO	
	N2O	YES	L, T
1.A.2. Manufacturing Industries and Construction			
Liquid fuels	CH4	NO	
	N2O	NO	
Solid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	NO	
	N2O	NO	
Other fuels	CH4	NO	
	N2O	NO	
1.A.3. Transport			
a. Civil Aviation	CH4	NO	
	N2O	YES	T
b. Road Transportation			
Gasoline	CH4	NO	
Cars with Catalytic Converters	N2O	YES	L, T
Cars without Catalytic Converters	N2O	YES	T
Diesel	CH4	NO	
	N2O	NO	
Natural gas	CH4	NO	
	N2O	NO	
c. Railways	CH4	NO	
	N2O	NO	
d. Navigation			
Residual Oil & Gas/Diesel Oil	CH4	NO	
	N2O	NO	
Gasoline	CH4	NO	
	N2O	NO	

IPCC Source Categories	Direct Greenhouse Gas	Key Source Category	Criteria of identification[1]
e. Other Transportation			
Liquid fuels	CH4	NO	
Gasoline	N2O	NO	
Diesel	N2O	NO	
1.A.4. Other Sectors			
Liquid fuels	CH4 N2O	NO NO	
Solid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	YES	L, T
	N2O	NO	
Other fuels	CH4	NO	
	N2O	NO	
1.A.5. Other			
Liquid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
1.B. Fugitive Emissions from Fuels			
1.B.1 Solid Fuels			
Arable peatlands	CO2	YES	L, T
Peat production areas	CO2	YES	L, T
	CH4	NO	
1.B.2. Oil and Natural Gas	CO2	NO	
	CH4	NO	
2. Industrial Processes			
2.A.1 Cement Production	CO2	NO	
2.A.2 Lime Production	CO2	NO	
2.B.2 Nitric Acid Production	N2O	YES	L, T
2.B.5 Other	CH4	NO	
2.C Iron and Steel production	CH4	NO	
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs, PFCs	YES	T
2.F.2 Foam Blowing **2.F.4 Aerosols**	HFCs HFCs	NO NO	
2.F.7 Electrical Equipment	SF6	NO	
2.F Other (grouped data)	HFCs, PFCs, SF6	NO	
3. Total Solvent and Other Product Use	N2O	NO	
4. Agriculture			
4.A. Enteric fermentation	CH4	YES	L, T
4.B. Manure management	CH4	NO	
4.B. Manure management	N2O	YES	L, T
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N2O	YES	L, T
4.D. Agricultural soils: indirect emissions	N2O	YES	L, T

IPCC Source Categories	Direct Greenhouse Gas	Key Source Category	Criteria of identification[1]
6. Waste			
6.A. Solid Waste Disposal on Land	CH_4	YES	L, T
6.B.1 Industrial Wastewater	CH_4	NO	
6.B.2 Domestic and Commercial Wastewater			
sparsely populated areas	CH_4	NO	
densely populated areas	CH_4	NO	
sparsely populated areas	N_2O	NO	
densely populated areas	N_2O	YES	L, T
6.B.3. N input from Fish Farming	N_2O	NO	
6.B.3. N input from industrial wastewater	N_2O	NO	
7.Other - non-energy use of fuels	CO_2	YES	L

[1] L=level, T=trend

TABLE F. Source category analysis for base year.

Quantitative Method Used: Tier 2			
A	B	C	D
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category**	**Criteria of identification**
1.A. Fuel Combustion			
Liquid fuels	CO2	YES	L
Solid fuels	CO2	YES	L
Gaseous fuels	CO2	NO	
Other fuels	CO2	YES	L
1.A.1 Energy Industries			
Liquid fuels	CH4	NO	
	N2O	NO	
Solid fuels	CH4 N2O	NO NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	NO	
	N2O	NO	
Other fuels	CH4	NO	
	N2O	YES	L
1.A.2. Manufacturing Industries and Construction			
Liquid fuels	CH4	NO	
	N2O	NO	
Solid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	NO	
	N2O	NO	
Other fuels	CH4	NO	
	N2O	NO	
1.A.3. Transport			
a. Civil Aviation	CH4	NO	
	N2O	NO	
b. Road Transportation			
Gasoline	CH4	NO	
Cars with Catalytic Converters	N2O	NO	
Cars without Catalytic Converters	N2O	YES	L
Diesel	CH4	NO	
	N2O	NO	
Natural gas	CH4	NO	
	N2O	NO	
c. Railways	CH4	NO	
	N2O	NO	
d. Navigation			
Residual Oil & Gas/Diesel Oil	CH4	NO	
	N2O	NO	
Gasoline	CH4	NO	
	N2O	NO	

IPCC Source Categories	Direct Greenhouse Gas	Key Source Category	Criteria of identification
e. Other Transportation			
Liquid fuels	CH4	NO	
Gasoline	N2O	NO	
Diesel	N2O	NO	
1.A.4. Other Sectors			
Liquid fuels	CH4 N2O	NO NO	
Solid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
Biomass	CH4	YES	L
	N2O	NO	
Other fuels	CH4	NO	
	N2O	NO	
1.A.5. Other Liquid fuels	CH4	NO	
	N2O	NO	
Gaseous fuels	CH4	NO	
	N2O	NO	
1.B. Fugitive Emissions from Fuels			
1.B.1 Solid Fuels			
Arable peatlands	CO2	YES	L
Peat production areas	CO2	YES	L
	CH4	NO	
1.B.2. Oil and Natural Gas	CO2	NO	
	CH4	NO	
2. Industrial Processes			
2.A.1 Cement Production	CO2	NO	
2.A.2 Lime Production	CO2	NO	
2.B.2 Nitric Acid Production	N2O	YES	L
2.B.5 Other	CH4	NO	
2.C Iron and Steel production	CH4	NO	
2.F.1. Refrigeration and Air Conditioning Equipment	HFCs, PFCs	NO	
2.F.2 Foam Blowing **2.F.4 Aerosols**	HFCs HFCs	NO NO	
2.F.7 Electrical Equipment	SF6	NO	
2.F Other (grouped data)	HFCs, PFCs, SF6	NO	
3. Total Solvent and Other Product Use	N2O	NO	
4. Agriculture			
4.A. Enteric fermentation	CH4	YES	L
4.B. Manure management	CH4	NO	
4.B. Manure management	N2O	YES	L
4.D. Agricultural soils: direct emissions, animal production and sludge spreading	N2O	YES	L
4.D. Agricultural soils: indirect emissions	N2O	YES	L

IPCC Source Categories	Direct Greenhouse Gas	Key Source Category	Criteria of identification
6. Waste			
6.A. Solid Waste Disposal on Land	CH4	YES	L
6.B.1 Industrial Wastewater	CH4	NO	
6.B.2 Domestic and Commercial Wastewater			
sparsely populated areas	CH4	NO	
densely populated areas	CH4	NO	
sparsely populated areas	N2O	NO	
densely populated areas	N2O	YES	L
6.B.3. N input from Fish Farming	N2O	NO	
6.B.3. N input from industrial wastewater	N2O	NO	
7.Other - non-energy use of fuels	CO2	YES	L

[1] L=level, T=trend