Preparation of the GHG Inventory for the Second National Communication under UNFCCC

National Inventory Summary Report

FINAL VERSION

ICEIM-MANU
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Preface

The GHG Inventory in Macedonia was prepared for the first time as a part of the First National Communication on Climate Change, where the three main GHG - CO_2, CH_4 and N_2O are inventoried for the period 1990-1998. Macedonian inventory team used IPCC methodology, recommended by the UNFCCC, explained in details in the Revised 1996 IPCC Guidelines for National GHG Inventories. As prescribed by this methodology, the GHG inventory comprised the following sectors: Energy, Industrial Processes, Agriculture, Land-use Change and Forestry, and Waste. This inventory has undergone substantial national peer-review, and also received technical feedback, provided by the National Communications Support Unit (NCSU).

However, generally speaking, the GHG Inventory process for the First National Communication on Climate Change did not incorporate many of the good practice elements defined in the IPCC Good Practice Guidance and Uncertainty Management, 2000. Also, in accordance with the national circumstances many data gaps in the activity data (particularly in the waste sector) were identified, as well as the simplest methods (Tier 1) for emissions calculation were applied.

Under the Second National Communication the main goal regarding the GHG inventorying was to prepare national GHG inventories for the years 1999-2002, according to the guidelines for the preparation of National Communications (17/CP.8). In addition, some efforts were undertaken to perform the following specific tasks:

- Inclusion of information on the other non-direct GHGs: HFCs, PFCs and SF6 as well as CO, NOx, SOx and NMVOCs.
- Revision of the input data, taking into consideration data gaps and areas needing improvement identified in the stocktaking exercise
- Identifying and developing methods for overcoming data gaps
- Application of higher Tiers (more sophisticated methods) for emissions calculation wherever possible
- Inclusion of the Use of Organic Solvents and Other Compounds Sector into the national inventory whenever possible (for the years when the relevant activity data are available)
- Recalculation of the time series for the period 1990-1998
- Developing a full documentation of activity data and emission factors for the year 2000
- Implementation of good practice elements to maximal possible extent

This resulted in (more) reliable time series 1990-2002 for the national GHG Inventories, reported in the National Inventory Report (NIR), complete and consistent

EXCEL database (1996 IPCC EXCEL Spreadsheets), appended by the full documentation of activity data and emission factors for the year 2000 (Documenting material).

The GHG inventory process under the Second National Communication involved the following steps:

1. Identification of Data Sources
2. Entering the Activity Data and Emission Factors
3. Calculating the Emissions
4. Checking and Validation of Input Data
5. Recalculation and Validation of Emissions Estimates
6. Key Sources Analysis
7. Uncertainty Management
8. National Expert and Public Review
9. International Peer-review
10. Reporting the Emissions

The national GHG inventory team was structured in a way that it enables control and assurance of quality of input data and estimated emissions to maximal possible extent. Namely, the national GHG inventory team involved the following entities:

Ministry of Environment and Physical Planning (MoEPP), having the responsibilities for:

- Supervising the national inventory process, and
- International reporting the emissions.

National Institution (NI), which

- Acted as a National Inventory Team Leader (**NITL**)
- Maintained the whole GHG inventory,
- Incorporated good practice elements such as key sources analyses, uncertainty management, QA/QC procedures, documenting and archiving, and
- Reported the emissions to MoEPP
- Coordinated and supervised the **Sectoral Experts** (two experts for each sector)**:**

  Enterer, responsible for identification/verification of data sources, entering and documenting the input data, and

  Checker, responsible for checking and validating the input data and emission estimates.

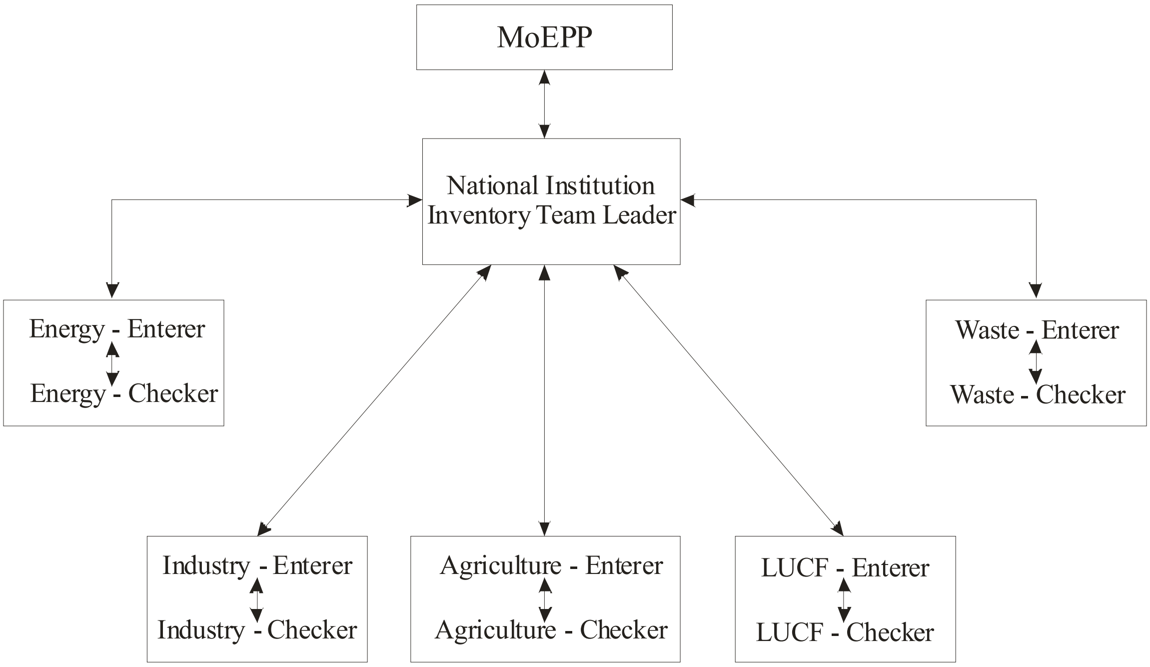

Figure 1: Structure of the national GHG inventory team

The national institution appointed as National Inventory Team Leader, was the Research Center for Energy Informatics and Materials of the Macedonian Academy of Sciences and Arts (ICEIM-MANU). The core team of the ICEIM-MANU was composed of the following experts:

Acad. Jordan Pop-Jordanov
Acad. Tome Bosevski
Dr. Natasa Markovska
Dr. Mirko Todorovski

The wider GHG Inventory team involved the Sectoral experts, as listed below:

Energy

Dr. Mirko Todorovski, Enterer; Ass.Prof. Risto Filkovski , Checker

Industry

Dr. Bosko Nikov, Enterer; Prof. Trajce Stafilov, Checker

Agriculture

Prof. Vladimir Dzabirski, Enterer; Ass. Prof. Dusko Mukaetov, Checker

Land Use Change and Forestry

Ass.Prof. Ljupco Nestorovski, Enterer; Ass. Prof. Nikola Nikolov, Checker

Waste

Prof. Trajce Stafilov, Enterer; Dr. Bosko Nikov, Checker

1. Energy

The inventory for the Energy sector under the Second National Communication (SNC) is prepared for the period 1990-2002, with consideration of the three main GHGs: CO_2, CH_4 and N_2O, as well as the indirect gases CO, NOx, NMVOC and SO_2.

The inventory comprises the emissions resulting from fuel combustion as well as the fugitive emissions from extraction, transmission and distribution of solid, liquid and gaseous fuels. Practically all activity data are taken from the energy balances which are issued annually by the State Statistical Office and they are containing data for all fuel activities by sectors according to the EUROSTAT methodology. Such publications are available for the period 1998-2002.

The CO_2 emissions are calculated by two methods: Reference approach (top-down) – uses the apparent fuel consumption accounting for the carbon flows into and out of the country and Sectoral approach (bottom-up) – accounts for the fuel consumption by sectors.

According to the IPCC methodology, the emissions in the sectoral approach are separated in the following categories: Energy Industries, Manufacturing Industries and Construction, Transport, Commercial/Institutional & Residential, Agriculture/Forestry/Fishing and Other.

The emissions are calculated with the IPCC Excel software using the emission factors provided in the IPCC Guidelines for all fuels except lignite. In addition to the default emission factors, national CO_2 emission factor for the lignite was developed and applied and the misuse of the default lignite fugitive emissions factor was overcomed.

In the inventory from the FNC, the lignite emissions both CO_2 and fugitive, have been recalculated for the period 1990-1997. As an extension, completely new inventories have been prepared for the period 1998-2002 using the Tier 1 approach.

As a supplemet to the IPCC Excel spreadsheets, data documentation tables have been prepared. Specialy developed auxiliary software was used to automatically fill the IPCC spreadsheets and create documentation and reporting tables avoiding any typing errors. The inventory documentation is detailed and clear, so that an independent analyst can obtain and review the references used and reproduce the emission estimates.

Possible application of the Tier 2 methodology was considered, but it was concluded that at this moment it can not be applied at all, since the data for the fuel consumption by technology types are not available in any official publication in Macedonia according to the requirements of the methodology.

The Reference Approach provides a method to estimate the total CO_2 emissions from fuels supplied to the country but it does not break down the emissions by sectors. Sectoral breakdown of CO_2 emissions using the defined IPCC source categories can serve as a base for determination of the key sources in the GHG inventory and a guide for the definition of the most appropriate GHG abatement policy, therefore only the results of the later approach will be presented here.

The detailed calculations used in the Sectroal Approach are essentially similar to those used for the Reference Approach. The only difference is that instead of a country's apparent consumption here we use the fuel consumption for each sector separately, accompanied by corresponding conversion and emission factors. In such way we are able to calculate the CO_2 emissions for each fuel in each sector.

In the Sectoral Approach, the Energy sector also includes a sectors related to fugitive emissions from fuels (lignite mining and transmission and distribution of liquid fuels and natural gas).

In Tables 1.1-1.2 the consumption, conversion and emission factors by fuel types for all subsectors for the base year (2000) are presented. For some fuels in certain sectors, the fuel consumption from the energy balance could not be put in the IPCC software simply because there is no such category (e.g. bitumen in Manufacturing Industries and Constructions, Lubricantrs in Transport, etc.). In order to calculate the emissions from these fuels we had to put them in other sectors, which is clearly marked in the tables with asterisks.

The CO_2-eq emissions from the Energy sector for the period 1990-2002 are presented in Table 1.3 where we present the emissions by subsectors. In addition, in the lower part of the table we present the contribution of individual subsectors to the total CO_2-eq emissions in the Energy Sector. This table clearly indicates that the main contributor to the CO_2-eq emissions within the energy sector is the Energy industries subsector, which produces about 70-75% of the total emissions. The Transport sector contributes with about 10-15%, while all other sectors are contributing with a few percents each.

Table 1.4 presents the contribution of individual GHGs to the total CO_2-eq emissions in the Energy Sector. About 97% of the equivalent emissions are direct CO_2 emissions from fuel burning and almost 3% are the fugitive CH_4 emissions. The N_2O are negligible.

Comparing the recalculated CO_2-eq emissions for the years 1990-1998 with the corresponding ones reported in the First National Communication we can notice a significant difference. The recalculated emissions are about 6-14% lower exclusively due to the different lignite emissions, both direct CO_2 emission from lignite burning and the fugitive CH_4 emissions from lignite mining. In absolute values the emissions are 650-1,350 kt CO_2-eq lower for the years 1990-1998.

The situation concerning the activity data for the Inventory of GHG for the Second National Communication (SNC) is much better. The inventory is extended to include the years 1999-2002, for which there is an officially published Energy Balance (available for the years 1998-2002). The 1998 inventory was completely reconstructed and new inventories for the years 1999-2002 were built using the high quality data from the Energy Balance. Therefore, we may conclude that for the Energy sector the gaps in the activity data are not critical any more.

Quite different is the position in the case of conversion and emission factors, which are not elaborated in details in the Energy Balance used for the SNC. This shortcoming was identified in the inventory reports (progress reports) for the SNC and some measures for overcoming data gaps are suggested.

Although the recalculated emissions are not much different from the original ones, the frequent alternation of approaches and methods for lignite conversion and emission factors calculation clearly indicates that this might be considered as a gap. We acknowledge that much effort was put to solve the problem, but it seems that the final solution has not been found yet. Since the lignite emissions alone are about half of the total national emissions we suggest development of a study, which will either theoretically or experimentally derive reliable lignite conversion and CO_2 emission factor. In addition, we suggest the fugitive emissions to be considered in the same study as well.

In the report for the SNC it is explained that at the moment the Tier 2 methods can not be applied. When this statement was made, probably the Tier 2 methods have been looked upon as methods which completely exclude the Tier 1 method, meaning that all fuel consumption should be disaggregated down to the last combustion technology regardless of its size and contribution to the total emissions.

The Tier 2 methods can be partially applied, for example for some crucial plants, while the rest of the combustion technologies could be grouped by sub-sectors and Tier 1 method can be used. Having this in mind as well as the importance of the lignite in Macedonia, which is practically burned at two locations (Bitola and Oslomej), as a complement to the recommendation of the previous section we suggest in future that the lignite emission should be calculated with Tier 2 method, i.e. for both plants separately. Therefore, it is recommended to develop conversion and emission factors for both lignite mines separately.

Table 1.1. Fuel Consumption [kt] by Subsectors in the Energy Sector for the Base Year (2000)

Р. бр.	Видови на горива	Fuels	Енергетски трансфор. / Energy Industries	Индустрија / Manufacturing Ind. & Constr.	Железнички сообраќај / Rail Transport	Патен сообраќај / Road Transport	Воздушен сообраќај / Domestic Aviation	Домаќинства / Residential Sector	Земјодел-ство / AFF	Други сектори / Other	Неенерг. цели / Non-Energy Use	**Вкупно / Total**
			Subsectors/Подсектори									
1	Камен јаглен	Other Bituminous Coal	0.457	-	-	-	-	-	-	-	-	**0.457**
2	Кокс	Coking Coal	-	-	-	-	-	-	-	-	-	**-**
3	Лигнит	Lignite	7,670.819	-	-	-	-	22.654	1.004**	5.577	-	**7,700.054**
4	Сурова нафта	Crude Oil	-	-	-	-	-	-	-	-	-	**-**
5	Влезни суровини	Refinery Feedstocks	168.666	-	-	-	-	-	-	-	-	**168.666**
6	ТНГ	LPG	2.474	14.472	-	1.981	-	6.396	0.009	7.387	0.050	**32.769**
7	Моторен бензин	Gasoline	-	0.004	-	143.760	0.027	-	1.060	-	-	**144.851**
8	Керозини	Jet Kerosene	-	0.228	-	-	27.612	-	-	-	-	**27.840**
9	Примарен бензин	Naphtha	-	-	-	-	-	-	-	-	-	**-**
10	Дизел и гориво за ложење	Gas / Diesel Oil	16.758	54.360	4.192	165.416	0.295**	25.449	11.805	31.185	0.076	**309.536**
11	Мазут	Residual Fuel Oil	236.142	77.761	-	-	-	-	28.590	-	-	**342.493**
12	Други нафтени производи	Other Oil	-	-	-	-	-	-	-	0.355***	0.003	**0.358**
13	Чист спирт	White Spirit	-	-	-	-	-	-	-	-	0.604	**0.604**
14	Масла и мазива	Lubricants	0.245	-	0.025**	9.450**	0.003**	-	0.280**	0.002	1.297	**11.302**
15	Битумен	Bitumen	-	-	-	-	-	-	-	-	2.770	**2.770**
16	Нафтен кокс	Petroleum Coke	-	-	-	-	-	-	-	-	-	**-**
17	Природен гас*	Natural Gas	58,341.722	8,638.011	-	-	-	-	-	-	-	**66,979.733**
18	Дрво*	Wood	35.462	8.090	-	-	-	767.383	-	85.428	-	**896.363**

* 1000 m^3; ** In the IPCC software considered as fuel consumption in "Other"; *** In the IPCC software considered as Gas/Diesel Oil consumption in "Other"

Table 1.2. Conversion and Emission Factors by Fuel Types for All Subsectors within the Energy Sector for the Base Year (2000)

Р. бр.	Видови на горива	Fuels	Conversion Factor [TJ/kt]	Emission factor [t C/TJ]	Fraction of Carbon Oxidised
1	Камен јаглен	Other Bit. Coal	27.630	25.8	0.98
2	Кокс	Coking Coal	26.923	25.8	0.98
3	Лигнит	Lignite	10.385*	30.4**	0.98
4	Сурова нафта	Crude Oil	42.400	20.0	0.99
5	Влезни суровини	Refinery Feedstocks	43.766	20.0	0.99
6	ТНГ	LPG	47.048	17.2	0.995
7	Моторен бензин	Gasoline	43.946	18.9	0.99
8	Керозини	Jet Kerosene	44.597	19.5	0.99
9	Примарен бензин	Naphtha	-	20.0	0.99
10	Дизел и гориво за ложење	Gas / Diesel Oil	42.961	20.2	0.99
11	Мазут	Residual Fuel Oil	40.999	21.1	0.99
12	Други нафтени производи	Other Oil	40.201	20.0	0.99
13	Чист спирт	White Spirit	40.201	20.0	-
14	Масла и мазива	Lubricants	40.201	20.0	0.99
15	Битумен	Bitumen	40.201	22.0	0.99
16	Нафтен кокс	Petroleum Coke	30.988	27.5	0.99
17	Природен гас	Natural Gas	0.034	15.3	0.995
18	Дрво	Wood	9.927	29.9	0.98

* 7.080 for Energy Industries (Енергетски трансформации) and 10.005 for Manufacturing Industries and Construction (Индустрија)

** This value is used for Energy Industries only, for all other subsectors 27.6 was used

Table 1.3. Contribution of individual subsectors to the total CO_2-eq emissions in the Energy Sector

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	Energy industries	6,937.771	6,314.560	5,951.331	6,122.003	6,333.226	6,409.249	5,958.255	6,583.705	7,492.262	7,079.011	6,876.433	7,345.690	6,540.728
	Fugitive emissions	151.042	140.236	136.268	139.772	148.134	153.553	146.884	157.479	180.890	169.827	181.077	200.583	190.498
	Transport	1,055.464	1,032.945	860.248	1,209.582	1,097.153	1,095.501	1,145.692	1,122.715	1,061.918	1,191.280	1,068.395	1,011.427	1,083.900
	Manufacturing industries and construction	968.942	918.637	812.913	844.301	656.479	665.074	704.429	731.958	585.356	438.427	569.913	380.541	448.143
	Commercial/Institutional & Residential	580.388	552.107	518.134	531.570	431.879	426.797	436.837	405.706	205.197	222.952	242.597	213.053	223.074
	Agriculture/Forestry/Fishing	246.228	231.973	205.273	221.160	172.691	174.837	186.188	196.717	144.438	102.361	131.134	108.230	59.810
	Other	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	269.081	512.521	157.358	96.175	1,209.377
	Total	**9,939.834**	**9,190.459**	**8,484.167**	**9,068.388**	**8,839.563**	**8,925.011**	**8,578.286**	**9,198.279**	**9,939.144**	**9,716.381**	**9,226.906**	**9,355.699**	**9,755.530**
[%]	Energy industries	69.80	68.71	70.15	67.51	71.65	71.81	69.46	71.58	75.38	72.86	74.53	78.52	67.05
	Fugitive emissions	1.52	1.53	1.61	1.54	1.68	1.72	1.71	1.71	1.82	1.75	1.96	2.14	1.95
	Transport	10.62	11.24	10.14	13.34	12.41	12.27	13.36	12.21	10.68	12.26	11.58	10.81	11.11
	Manufacturing industries and construction	9.75	10.00	9.58	9.31	7.43	7.45	8.21	7.96	5.89	4.51	6.18	4.07	4.59
	Commercial/Institutional & Residential	5.84	6.01	6.11	5.86	4.89	4.78	5.09	4.41	2.06	2.29	2.63	2.28	2.29
	Agriculture/Forestry/Fishing	2.48	2.52	2.42	2.44	1.95	1.96	2.17	2.14	1.45	1.05	1.42	1.16	0.61
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.71	5.27	1.71	1.03	12.40
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 1.4. Contribution of individual GHGs to the total CO_2-eq emissions in the Energy Sector

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	CO_2	9,469.008	8,737.395	8,049.026	8,592.552	8,377.756	8,469.744	8,136.003	8,796.541	9,509.592	9,288.604	8,791.000	8,934.373	9,348.403
	CH_4	227.778	215.088	213.850	219.343	220.734	222.182	212.375	203.411	228.359	219.408	237.438	245.461	235.068
	N_2O	47.401	44.352	42.829	44.747	43.306	42.959	40.857	39.450	43.907	42.644	42.478	41.783	38.941
	CO	195.648	193.624	178.462	211.745	197.768	190.127	189.050	158.877	157.285	165.724	155.991	134.082	133.118
	Total	9,939.834	9,190.459	8,484.167	9,068.388	8,839.563	8,925.011	8,578.286	9,198.279	9,939.144	9,716.381	9,226.906	9,355.699	9,755.530
[%]	CO_2	95.26	95.07	94.87	94.75	94.78	94.90	94.84	95.63	95.68	95.60	95.28	95.50	95.83
	CH_4	2.29	2.34	2.52	2.42	2.50	2.49	2.48	2.21	2.30	2.26	2.57	2.62	2.41
	N_2O	0.48	0.48	0.50	0.49	0.49	0.48	0.48	0.43	0.44	0.44	0.46	0.45	0.40
	CO	1.97	2.11	2.10	2.33	2.24	2.13	2.20	1.73	1.58	1.71	1.69	1.43	1.36
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

2. Industry

For the purpose of the Macedonian Second Communication on Climate Change, an inventory of emissions of greenhouse gases for the period 1999-2002 has been made following the IPCC methodology. The year 2000 is the base year and more detailed information has been provided for that particular year.

A revision of the GHG Inventory prepared for the First National Communication on the Climate Change has been carried out prior to preparing the GHG Inventory for the SNC.

The GHG Inventory for FNC consists of data on CO_2, N_2O and CH_4 emissions from mineral, chemical and metals industries.

Simultaneously with preparing the present inventory, the one prepared for the FNC was updated.

The reported inventory contains data on emissions of 8 gases from the industrial sector: CO_2, CH_4, HFC, SF_6, CO, SO_2, NOx and NMVOC.

In addition to the mineral, metal and chemical industries reported in the inventory for the FNC, the present inventory contains emissions from food industry as well as emissions arisen from use of HFCs and SF_6.

Official data on production activities were given high priority in the data entry process. Therefore most of the data have been extracted from relevant editions of the State Statistics Office.

As far as the emission factors are concerned, those given in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories were used whenever available. The electronic version of the emission factors database was of very little help.

The retrieved production and emission factor data were inserted into the database and the respective emissions were calculated.

In most cases the Tier 1 of the IPCC methodology was used for emission estimation. In very few occasions (one single source of a kind) data were received directly from the operators.

This brief report contains data on the production rates of the selected industries in the reported period 1999-2002, a summary table of the GHG emissions in the period 1990-2002 followed by comments, conclusions and recommendations.

Several characteristic features have to be kept in mind while assessing the GHG emissions from the Macedonian industry:

1. The overall industrial production in the Republic of Macedonia was reduced to 50% from 1990 to 1999.

2. Significant variations in production rates occurred due to small number of installations in some industrial sectors.
3. Data on some industrial sectors are available for only the most recent years, thus leading to a false conclusion of a sudden increase of emission of certain gas.
4. Some industries have been almost or completely exterminated such as: production of PVC, pig iron, ferrochromium and from 2003 the production of zinc.

Most of the greenhouse gases both direct and indirect have been reported in this inventory, but uncertainties have not been dealt with. As the industrial production rate stabilizes, more reliable data will be provided including the assessment how reliable these data are.

Most of the emissions are generated from rather a small number of installations. This fact should be considered as an advantage and be used for decreasing uncertainties. Direct communication between the sector expert and the industry preferably throughout the reporting period is the best possible way and will enable to apply Tier 2 to some subsectors.

It is difficult, but not impossible to incorporate GHG emissions in the reporting scheme of the A and B IPPC installations. It may be a matter of a separate project to train the responsible staff within the industry on the IPCC methodology.

Road paving with asphalt should be the next activity to be included in the list of reported sources for National communications on GHG emissions.

CO_2 emissions from lime production are well established in GHG reporting. However, no reports have so far been met dealing with CO_2 sink related to lime used in civil engineering. IPCC should consider this chapter too.

Table 2.1. Industrial production in Macedonia in the period 1999-2002

Industry	Production/Consumption (t)			
	1999	2000	2001	2002
Mineral				
Cement	563291	801099	585436	715825
Lime	4264	13019	13422	10890
Dolomitic lime	686	264		
Dolomite use	5109	1262	313	320
Limestone Use	3723	268	1929	2168
Soda Ash use	3677	2507	2615	2818
Metallurgy				
Iron and steel production	46721	161063	227582	231686
Steel manufacturing	461818	695357	395890	291636
Ferro-alloys	79169	57842	58520	28528
Ferro-silicon	54127	41170	27287	0
Ferro-manganese	0	0	0	0
Ferro-nickel	1432		31233	28528
Ferro-chromium	0	0	0	0
Silicon-manganese	23610	16672	0	0
Slab Zinc Production	53304	64070	60518	59633
Chemical Industry				
PVC	14606	5450	2480	4493
Sulphuric Acid	87770	108626	101058	94895
Methanol	0	167	0	0
Food and beverage				
Wine	717452	961419	338992	179517
White wine			560185	276318
Spirits	14301	9480	12454	8477
Beer	652165	660838	617843	657252
Bread	72112	67183	53850	51516
Meat	4724	4784	6384	7215
Sugar	43038	31924	31924	36614
Cakes	4406	4571	4241	4217
Coffee Roasting	138	159	215	222
Margarine	2615	2407	2223	2144
HFC/PFC+SF6	N. A.	158	319	120
HFC		158	319	120
PFC	0	0	0	0

Table 2.2. GHG emissions from industrial sector [kt]

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
kt	Mineral Industry	350.80	327.14	285.90	273.03	258.18	277.11	254.65	311.10	234.14	290.39	411.54	304.53	367.66
	Metal Industry	538.49	581.56	671.87	558.21	458.27	516.00	565.01	599.14	659.12	452.04	448.95	504.02	385.67
	Chemical Industry	0.00	0.00	0.00	0.21	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Food and Drinks	0	0	0	0	0	0	0	0	0	0	0	0	0
	Use of HFC i SF_6										8.35	33.57	128.84	39.04
	Total	**889.29**	**908.70**	**957.77**	**831.46**	**716.66**	**793.32**	**819.66**	**910.24**	**893.26**	**750.79**	**894.06**	**937.39**	**792.37**
%	Mineral Industry	39.45	36.00	29.85	32.84	36.02	34.93	31.07	34.18	26.21	38.68	46.03	32.49	46.40
	Metal Industry	60.55	64.00	70.15	67.14	63.95	65.04	68.93	65.82	73.79	60.21	50.21	53.77	48.67
	Chemical Industry	0.00	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Food and Drinks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Use of HFC i SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	3.75	13.74	4.93

Table 2.3. Contribution of individual GHGs to the total CO2-eq emissions from the Industrial sector

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO2	818.59	838.81	886.89	766.53	664.13	738.18	755.52	835.86	828.86	676.01	780.65	733.13	679.02
CH4	-	0.19	-	0.12	0.11	0.17	0.05	0.05	0.05	-	0.01	-	-
CO	70.70	69.89	70.89	64.71	52.32	54.93	74.04	74.39	73.35	66.43	79.84	75.41	74.31
HFC+SF_6	-	-	-	-	-	-	-	-	-	8.33	33.53	128.80	36.04
Total	**889.29**	**908.89**	**957.78**	**831.36**	**716.56**	**793.28**	**829.61**	**910.30**	**902.27**	**750.77**	**894.03**	**937.35**	**789.38**
CO_2	92.05	92.29	92.60	92.20	92.68	93.05	91.07	91.82	91.86	90.04	87.32	78.21	86.02
CH4	-	0.02	-	0.01	0.02	0.02	0.01	0.01	0.01	-	0.00	-	-
CO	7.95	7.69	7.40	7.78	7.30	6.92	8.92	8.17	8.13	8.85	8.93	8.05	9.41
HFC+SF_6	-	-	-	-	-	-	-	-	-	1.11	3.75	13.74	4.57
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

3. Agriculture

The inventory revision in the Agricultural Sector (1990-1998) and the new inventory (199-2002) are conducted according to the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

At this moment the available input data are in correlation with the request of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories for application of the Tier 2 method. Therefore revision and new inventory allow application of the Tier 1 method. The implementation of the more complex Tier 2 method requires country-specific information for sector Agriculture. Implementation of more sophisticated method (Tier 2) in the future inventories can be accepted if experts pose data which will be in accordance with the Tier 2 methodology. To achieve this request certain changes, rearrangements, should be done in the field of data collections and approximation of our statistical office with Eurostat.

The main problem is the absence of relevant statistical department within the Ministry of Agriculture, Forestry and Water Economy (MAFWE) and non-existence of appropriate systems which will serve as a reliable and constant source of field data which will be further on statistically appropriate elaborated and delivered to the State Statistical Office for further integration with other relevant data.

Collection of activity data for realization of this inventory, concerning the agriculture sector is based on official data of the State Statistical Office of the Republic of Macedonia as a key source. Greenhouse gases emissions are computed using data for each category and each sub-sector further multiplied by the specific emission factors, which are estimated separately for each year.

The GHG Inventory for Agriculture is based on the data for the following gases: CH_4, N_2O and CO_2-eq, and their emission from the following source categories:

- CH_4 emissions from enteric fermentation in domestic livestock,
- CH_4 emissions from manure management,
- N_2O emissions from manure management,
- CH_4 and N_2O emissions from agricultural residue burning,
- Direct N_2O emissions from agricultural soils,
- Indirect N_2O emissions from nitrogen used in agriculture,
- CH_4 emissions from rice production.

Other gases such as: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) and SO_2 are not specific, characteristic for agriculture.

The emissions of CO_2-eq from agriculture for the period 1990-2002 are given by subsectors in Table 3.1. In addition, in the lower part of the table the contribution of the individual subsectors are presented. It is evident that the main sources of the emissions are the enteric fermentation and agricultural soils, both with about 40-50% of the total CO_2-eq emissions. Table 3.2 presents the contributions of the individual GHGs in the total CO_2-eq for the agriculture.

In the revised document for the Total Annual Methane Emissions from Domestic Livestock (kt) during the period 1990 -1998, it is shown that there is a significant difference in poultry species. Furthermore, because of the lack of official statistic data for the number of goat population in the Republic of Macedonia, goats are not included in further analysis. Also there in no official data for the number of mules and asses and they are excluded from the calculation.

Slight difference in the present number of non-dairy cattle in the Republic of Macedonia has no significant influence on the final amount of Nitrogen Excretion per AWMS from Solid Storage and Drylot.

The values for CH_4 Emissions (kt) from rice fields in the revised inventory for agriculture in the period 1990-1998 have shown no significant difference with the value from the previous inventory.

Slight difference in Direct Nitrous Oxide Emissions from Agricultural Fields, Excluding Cultivation of Histosols between the present inventory revision and the previous inventory is due to difference in animal number (excluding goats, mules and asses to inventory revision).

Values for Direct Soil Emissions of nitrous oxide (kt N_20-N/yr) for the period 1990-1998 in the revised inventory have a significant importance in Animal waste (FAW) for year 1991 where the value is 0.40,whereas in the previous revision this value is 0.16.

In the revised inventory document the values for total nitrogen excretion for Manure Nitrogen Used for the period 1990-1998 have the lowest value compared with the previous document, because the goats, mules and asses are not included in calculation due to the absence of statistical data for these animals.

There is no change in the area of cultivated organic soils in the Republic of Macedonia, so therefore, the values for Direct Nitrous Oxide Emissions from Cultivation of Histosols are the same in both documents.

Indirect Nitrous Oxide Emissions from Atmospheric Deposition of NH_3 and NOx for the Period 1990-1998 have a different value for nitrous oxide emission due to the changes of the value for the total excretion by livestock NEX (kgN/yr).

Indirect Nitrous Oxide Emissions from Leaching for the inventory revision have a different value for nitrous oxide emission due to the changes of the value for the total excretion by livestock NEX (kgN/yr).

Current data from official Statistical Yearbooks of the Republic of Macedonia give opportunity for implementation of the Tier 1 method with restriction in some subsectors in the sector agriculture. For complete implementation of the Tier 1 method new type of data collection in the official Statistical Yearbooks needs to be implemented.

Table 3.1. Contribution of individual subsectors to the total CO_2-eq emissions in agriculture

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	Enteric Fermentation	694.38	684.25	697.77	703.11	704.98	692.21	659.46	634.65	567.86	570.48	559.46	560.30	545.42
	Manure Management	170.07	166.09	163.20	163.72	166.81	167.90	172.96	170.27	163.05	165.81	162.22	159.89	158.12
	Rice Cultivation	9.32	9.13	8.89	5.40	1.82	1.32	4.36	5.52	4.69	4.41	4.06	1.59	1.96
	Agricultural Soils	1,034.49	1,006.61	1,011.76	985.84	1,014.92	963.61	845.33	760.57	727.35	636.85	653.78	591.51	367.89
	Total	**1,908.27**	**1,866.08**	**1,881.62**	**1,858.08**	**1,888.54**	**1,825.04**	**1,682.11**	**1,571.02**	**1,462.96**	**1,377.56**	**1,379.52**	**1,313.29**	**1,073.39**
[%]	Enteric Fermentation	36.39	36.67	37.08	37.84	37.33	37.93	39.20	40.40	38.82	41.41	40.55	42.66	50.81
	Manure Management	8.91	8.90	8.67	8.81	8.83	9.20	10.28	10.84	11.15	12.04	11.76	12.17	14.73
	Rice Cultivation	0.49	0.49	0.47	0.29	0.10	0.07	0.26	0.35	0.32	0.32	0.29	0.12	0.18
	Agricultural Soils	54.21	53.94	53.77	53.06	53.74	52.80	50.25	48.41	49.72	46.23	47.39	45.04	34.27
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 3.2. Contribution of individual GHGs to the total CO_2-eq emissions in agriculture

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	CH_4	757.53	745.80	759.62	762.30	759.66	746.60	718.37	693.25	623.59	628.67	615.04	611.88	597.20
	N_2O	1,150.74	1,120.28	1,122.00	1,095.77	1,128.88	1,078.44	963.75	877.77	839.37	748.88	764.48	701.41	476.19
	Total	**1,908.27**	**1,866.08**	**1,881.62**	**1,858.08**	**1,888.54**	**1,825.04**	**1,682.11**	**1,571.02**	**1,462.96**	**1,377.56**	**1,379.52**	**1,313.29**	**1,073.39**
[%]	CH_4	39.70	39.97	40.37	41.03	40.22	40.91	42.71	44.13	42.63	45.64	44.58	46.59	55.64
	N_2O	60.30	60.03	59.63	58.97	59.78	59.09	57.29	55.87	57.37	54.36	55.42	53.41	44.36
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

4. Land Use Change and Forestry

According to the tasks from the Term of Reference, a revision of the existing inventory of GHG gases under the FNC for the period 1990-1998 was made, as well as the new inventory for the period 1999 – 2002 for the LUCF sector.

The revision showed small differences between the results, due to the small changes in the activity data. Mostly the same sources of activity data were used and same emission factors, so the difference is very litle.

The inventarisation from 1999 - 2002 was done using the Tier 1 methodology, because of the unavailability of accurate activity data that did not allow implementation of higher Tier methodology. Activity data were mainly used from the State Statistical Office of the Republic of Macedonia, and the default emission factors from the revised IPCC guidelines for GHG and its Manual. There were no new gases included.

The main problems during this inventarisation were located in the uncertainty of the activity data for the Forest area, stock and annual forest growth, changes in land use, as well as loss of biomass due to the commercial harvesting, illegal harvesting, wood decay in forest or the processed industry.

The data for Area of forest and other trees, forest growth and commercial harvest were taken from the Statistical Yearbook, and the data for the area burned from forest fires were taken from the Statistical Yearbook from the Ministry of Interior. Using these elements, the annual balance of abortion and emissions of the GHG gases, as well as the percentual parts for different gases, for the period 1990 – 2002, in this sector is shown in the next table and figures.

The highest contribution of the GHG gases is coming from the subsector Conversion of the forest and grassland, as well as from the on and off site burning of biomass.

In addition, in the table 4.2, the total as well as percentual part of the different GHG gases emmision from the LUCF sector is presented.

Table 4.1. CO_2 [kt] from the sector LUCF

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Biomass (removals)	1557.82	1609.85	1765.61	1896.71	1826.18	1805.67	1795.12	2249.23	2333.60	2202.05	2885.16	2616.27	2590.24
Soil (removals)	62.26	62.26	62.26	62.26	62.26	62.26	62.26	62.26	62.26	63.03	63.03	63.03	63.03
Forest and Grassland (release)	257.73	21.87	385.30	689.47	248.31	5.15	46.78	161.39	81.01	90.47	1711.95	291.90	31.65
TOTAL (removals)	**1362.35**	**1650.24**	**1442.57**	**1269.50**	**1639.95**	**1862.78**	**1810.60**	**2150.10**	**2314.85**	**2174.61**	**1236.24**	**2387.40**	**2621.62**

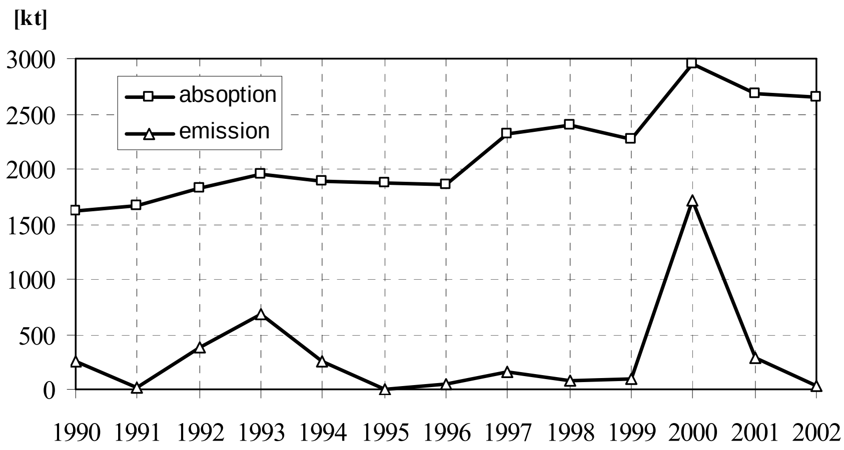

Figure 4.1. CO_2 from the LUCF sector

Land Use Change and Forestry is a very important sector for investigation for the overall balance of GHG gases for specific countries and globally, because it is the only sector that absorbs the emissions that are emitted from this and other sectors.The main emissions from this sector are coming from the annual loss of biomass for commercial harvest, the changes in biomass stock, the on and off side burning of biomass, wood decay and changes in land use. In the Republic of Macedonia, mostly, for the analyzed period, this sector absorbs all of its emissions, except for year 2000, because of the enormous number of forest fires, where the balance between absorption and emission is negative. In percents, the highest percentage of emissions are coming from burning biomass (on and off side), and the most frequent gas is CO_2, with over 97 %. Other gases are with very little contribution, except CO with little over 2%.

As a recommendation for the next inventarizations, it is necessary to make an accurate activity data that will produce results with higher precision and allow using higher Tier methodology. For that purpose, it is necessary to perform new forestry inventarization, that will determine the area, the stock, the annual growth, species and other information that are necessary to establish the emission of the GHG with higher precision. Also, it is necessary to have the real values of wood decay, number of forest fires, areas that are burned, percentage of burned wood, as well as estimation of wood used for heating, that is illegally cut and sold. There should be changes in the data that is collected from the State statistical office, in order to have the real and valide activity data for estimation of the GHG emission. There should be adjustments in the Ministry of Environment and Urban Planning, in order to have the information about the long term plans for land use, and provide the annual changes that are made.

Table 4.2. Contribution of individual GHGs to the total CO_2-eq emissions in the LUCF Sector

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	CO_2	251.41	21.28	374.79	670.66	241.53	5.02	45.65	156.99	78.81	88.00	1,664.95	283.88	30.77
	CO	6.15	0.52	9.19	16.45	5.93	0.12	1.12	3.85	1.93	2.16	40.85	6.97	0.76
	Nox	0.00	0.01	0.26	0.47	0.17	0.00	0.00	0.11	0.05	0.06	1.16	0.20	0.02
	CH4	0.17	0.06	1.05	1.88	0.68	0.01	0.01	0.44	0.22	0.25	4.67	0.80	0.09
	N2O	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.05	0.01
	Total	257.73	21.87	385.30	689.47	248.31	5.15	46.78	161.39	81.01	90.47	1,711.95	291.90	31.65
[%]	CO_2	97.55	97.30	97.27	97.27	97.27	97.48	97.59	97.27	97.29	97.27	97.25	97.25	97.22
	CO	2.39	2.38	2.38	2.38	2.39	2.33	2.39	2.39	2.38	2.39	2.39	2.39	2.40
	NOx	0.00	0.05	0.07	0.07	0.07	0.00	0.00	0.07	0.06	0.07	0.07	0.07	0.07
	CH4	0.06	0.27	0.27	0.28	0.27	0.19	0.02	0.27	0.27	0.27	0.27	0.27	0.28
	N2O	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.03
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

5. Waste

The Green House Gases (GHG) Inventory for the Second National Communication, the revision of the GHG Inventory for the Waste Sector under the FNC for the period of 1990-1998 and the GHG Sectoral inventory for the period 1999-2002, was made. The documentation of the Inventory Data for the year 2000 was enclosed as MS Word documents based on the provided template. At the end of the Report, the corrected values for methane and N_2O, and CO_2-equivalent emission for the period from 1990 to 2002 as total emissions (kt) from the Waste Sector are presented. The filled in Sectoral EXCEL Database for the year 1999, 2000, 2001 and 2002 are enclosed with this Report.

Input data (activity data and emission factors) for the whole period from 1990 to 2002 were entered in the data base and methane and N_2O emissions from the Waste Sector were calculated according to both: *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Workbook* and *Reference Manual*. Activity data were taken mainly from the *Statistical Yearbooks of the Republic of Macedonia*, published by the State Statistical Office of the Republic of Macedonia and the emission and conversion factors were taken from the *Revised 1996 IPPC Guidelines*.

In the Republic of Macedonia, data for the exact current annual amount of the waste, as well as historical waste quantities could not be obtained. Those data are available only for Drisla landfill disposing MSW from Skopje region. Because of that, the default method (Tier 1) was used in the Inventory for the GHGs from the Waste Sector based on the estimated amount of the MSW using the number of the population and the MSW Disposal Rate of 0.79 kg/capita/day. GHG Inventory for the Waste Sector was not extended with non-direct GHGs (HFCs, PFCs and SF_6, as well as CO, NO_x, SO_x and NMVOCs). It is known that there are no emission of HFCs, PFCs and SF_6 gases from waste sector. CO, NO_x, SO_x and NMVOCs could be emitted from the Waste Sector but mainly from the MSW incineration. There is no plant for MSW incineration in the Republic of Macedonia. Very small amounts of CO, NO_x and NMVOC could be SWDSs and waste-water treatment plants (approx. 0.3 % from the CH_4 emission from SWDSs) which negligible amount in total CO_2-equivalent emission for the country.

The GHG Inventory for the Waste Sector consists of the inventory of methane emission from different subsectoral sources (solid waste disposal sites, domestic/commercial organic wastewater and sludge and industrial wastewater and sludge) and N_2O emissions from human sewage for the period of 1999-2002 as well the corrected data for the inventory for the period of 1990-1998 (FNC).

Methane (CH_4) is emitted during the anaerobic decomposition of organic waste disposed of the solid waste disposal sites and during the handling of domestic and industrial waste water under anaerobic conditions. For the calculation of CH_4 emissions from solid waste disposal sites the following input data were used: total municipal waste (MSW) disposed to SWDSs, Methane Correction factor (MCF), fraction of Degradable Organic Component (DOC) in MSW, fraction of DOC which actually degrades, fraction of carbon released as methane, conversion ratio, recovered methane per year. All of those input data for 200 are given in Table 5.1. The total MSW disposed to SWDSs was calculated from the number of the total population in the country and the MSW Disposal Rate (taken to be constant for all the years of the analyzed period, with value of 0.79 kg/capita/day). The weighted average MCF depends on the proportion of waste which goes to each type of SWDSs (managed, unmanaged-deep, and unmanaged-shallow). In these calculations, only the amount of MSW disposed on Drisla landfill was calculated as solid waste disposed of managed SWDSs (with a MCF of 1), for the rest of the MSW up to the percentage of urban population (cities SWDs) of 60 % was used MCF of 0.8 (as unmanaged SWDSs deeper than 5 m) and for the rest of MSW was calculated with a MCF of 0.4 as for unmanaged shallow SWDs. For 2000 the Methane correction factor value for 0.70.

Table 5.1. Input data for calculation of the methane emission from SWDSs for 2000

Methane Correction Factor (MCF)	Fraction of DOC in MSW	Fraction of DOC which Actually Degrades	Fraction of Carbon Released as Methane	Recovered Methane per Year (kt CH_4)	One Minus Methane Oxidation Correction Factor	Total Annual MSW Disposed to SWDSs (kt MSW)
0.70	0.17	0.77	0.5	0	1	584.57

Most of the wastewater produced in the rural areas of the Republic of Macedonia is managed without formal handling and/or treatment systems. Therefore, the calculations were performed using only urban population (60 % of the whole population) and the factors given in the *Revised 1996 IPPC Guidelines*. The value for the methane conversion factor for the aerobic handling system is taken to be 0 and for anaerobic handling system it is taken to be 1. The maximum methane production capacity (in kg CH_4/kg BOD) amounts 0.25 kg CH_4 kg BOD, The fraction of wastewater treated by the aerobic handling system is taken to be 0.75. The emission factor for domestic/commercial wastewater is calculated to be 0.06 kg CH_4/kg BOD. Therefore, the emission from this subsector is also reduced for about 40 %.

To estimate methane emission from industrial wastewater and sludge the following data were entered: total industrial output for each industry (iron and steel, non-ferrous metals, fertilizer, food and beverage, paper and pulp, petroleum refining/petrochemicals, rubber, leather and tanning, textile, soap and detergent, pharmaceuticals, organic chemicals and plastics and resins), wastewater produced for each industry (in m^3/tonne product), degradable organic component (in kg COD/m^3 wastewater), fraction of DOC removed as sludge. Also, in order to estimate the emission factor for the industrial wastewater, values for fraction of wastewater treated by the handling system were considered.

N_2O emission from human sewage was estimated using a protein consumption of 33.9 kg proteins/person/year.

Using these corrected values for methane (solid waste disposal sites, domestic/commercial organic wastewater and sludge, and from industrial wastewater and sludge) and N_2O (from human sewage), and CO_2-equivalent emission for the period from 1990 to 2002 the total emissions (kt) from the Waste Sector is obtained. Summarized data are presented in Tables 5.2 and 5.3 giving the annual emissions of CO_2-equivalent emissions [kt] and the fraction of each GHG from the Sector Waste.

Methane and N_2O emission for the whole analyzed period is relatively constant, ranging from 755.15 kt CO_2-equivilent in 1994 to 843.56 kt CO_2-equivilent emission in 2000. Small increasing of methane emission appears in 1997 when the disposal of solid waste was increased at Drisla landfill (managed type of SWDSs). It is obvious that the bigger part of the GHG emission from the Waste Sector goes to the methane emission (about 93-94 % from the total emission in the Sector), while the smaller is the N_2O emission (6-7 %, calculated as CO_2-equivalent). The main emission of the GHG in the Waste Sector is the methane emission from the SWDSs (between 86-89 %), while the methane emission from domestic/commercial and industrial wastewaters and sludge is very small. Furthermore, there are plans for building managed SWDSs in the country, which will increase the emission of methane from the Waste Sector. Increasing of methane emission could be also expected by introducing the wastewater treatment plants for domestic/commercial and industrial wastewaters.

Table 5.2. CO_2-eq emission from subectors in Waste Sector

	Sebsector/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	SWDSs	677.67	682.50	695.73	699.09	655.41	675.78	691.95	728.70	736.05	735.84	749.91	742.56	748.65
	Domestic/Commercial Organic Wastewater and Sludge	33.81	34.23	34.86	35.28	33.39	33.81	28.56	28.77	28.77	28.98	29.19	29.19	28.98
[kt]	**Industrial Wastewater and Sludge**	21.21	24.36	21.21	19.32	13.65	17.01	12.18	12.18	12.60	10.29	11.76	10.92	9.45
	Human sewage	52.70	52.70	55.80	55.80	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70
	Total	**785.39**	**793.79**	**807.60**	**809.49**	**755.15**	**779.30**	**785.39**	**822.35**	**830.12**	**827.81**	**843.56**	**835.37**	**839.77**
	SWDSs	86.28	85.98	86.14	86.36	86.79	86.72	88.10	88.61	88.67	88.89	88.90	88.89	89.15
	Domestic/Commercial Organic Wastewater and Sludge	4.31	4.31	4.32	4.36	4.42	4.34	3.64	3.50	3.46	3.50	3.46	3.49	3.45
[%]	**Industrial Wastewater and Sludge**	2.70	3.07	2.63	2.39	1.81	2.18	1.55	1.48	1.52	1.24	1.39	1.31	1.12
	Human sewage	6.71	6.64	6.91	6.89	6.98	6.76	6.71	6.41	6.35	6.37	6.25	6.31	6.28
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 5.3. Contribution of GHGs in CO_2-eq emission in Waste Sector

	GHGs/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	CH_4	732.69	741.09	751.80	753.69	702.45	726.60	732.69	769.65	777.42	775.11	790.86	782.67	787.08
[kt]	**NO_2**	52.70	52.70	55.80	55.80	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70	52.70
	Total	**785.39**	**793.79**	**807.60**	**809.49**	**755.15**	**779.30**	**785.39**	**822.35**	**830.12**	**827.81**	**843.56**	**835.37**	**839.77**
		93.29	93.36	93.09	93.11	93.02	93.24	93.29	93.59	93.65	93.63	93.75	93.69	93.72
[%]	**NO_2**	6.71	6.64	6.91	6.89	6.98	6.76	6.71	6.41	6.35	6.37	6.25	6.31	6.28
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

6. Integral results

The total CO_2-eq emissions in Macedonia for the period 1990-2002 are presented in Table 6.1. From this table one can see that the main contributor to the total CO_2-eq emissions is the energy sector with about 70% of the total emissions. The second biggest contribution comes from the agriculture sector with about 10-15%, while all other sectors are contributing with less then 10% each. The only exception from this general conclusion is in the year 2000, when due to enormous forest fires the emissions from the LUCF sector are about 18% of the total national emissions. As an illustration, in Figure 6.1 we graphically show the contribution of the individual sectors to the total CO_2-eq emissions for the base year (2000) and for the last year (2002).

Table 6.2 presents the contribution of individual GHGs to the total CO_2-eq emissions, both in absolute values and in percents. About 75-80% of the equivalent emissions are direct CO_2 emissions from burning, 12-14% are the CH_4 emissions, 5-9% are the N_2O emissions and about 2% are the CO emissions. As an illustration, in Figure 6.2 we graphically show the contribution of the individual GHGs to the total CO_2-eq emissions for the base year (2000) and for the last year (2002).

Comparing the recalculated CO_2-eq emissions for the years 1990-1998 with the corresponding ones reported in the First National Communication we can notice a decrease in the range of 7.5-13.5%.

In the new inventory, all sectors report smaller emissions except the LUCF sector where the recalculated emissions are bigger. In absolute values the biggest reduction in the recalculated emissions in the range of 650-1,350 kt CO_2-eq are reported in the Energy sector. In this sector, the recalculated emissions are lower exclusively due to the different lignite emissions, both direct CO_2 emission from lignite burning and the fugitive CH_4 emissions from lignite mining. Most important factor leading to emission reduction was the correction in the fugitive emission factor for lignite mining, which was about 10 times higher in the inventory under the FNC. Namely, all lignite mines in Macedonia are surface, but in the FNC the default value for underground mines was used.

Significant reductions are also reported in the Sector of Industrial Processes in the range of 55-745 kt CO_2-eq and in the Waste Sector where the recalculated emissions are practically reduced by almost constant amount in the range of 360-400 for kt CO_2-eq all years. The Agriculture Sector reports 85-120 kt CO_2-eq smaller emission, while in the LUCF Sector the recalculated emissions are bigger than the old values for 4-540 kt CO_2-eq.

In relative values (percentages), the biggest differences in the recalculated emissions are found in the Sector of Industrial Processes (6-46%) and in the Waste Sector (30-34%). In the Energy Sector the recalculated emissions are about 6-14% lower and in the Agriculture Sector the emissions are 4-7% lower. Huge differences are found in the recalculated emissions from the LUCF sector, where the newly calculated emissions are about 3 times bigger.

As one of the indicators for the emission level, which may be used in comparative analyses with other countries is the CO_2-eq emissions per capita. For Macedonia, for the year 2002, the average value of this indicator amounts to 6.18 t CO_2-eq/capita. In Table 6.3 we present such indicators for the countries from Central and South East Europe, as well as for some of the most developed countries in the world. From the table we see that Macedonia is at the bottom with several times less emissions per capita than the developed countries. In addition, the emissions per capita are lower than in the other countries with economies in transition, which may reflect the overall economic situation in the country. Of course, this is partially true since the total CO_2-eq emissions not necessarily correspond to the general economic trend of the country. Some countries with large hydro share in the energy production may report low GHG emissions despite the relatively good economic position (e.q. Croatia). It is interesting to note that the Macedonian emissions per capita are higher then the corresponding emissions in some large countries such as: Turkey, Mexico, Brazil, China, Indonesia, Pakistan and India (descending order of emissions in the range 5 to 2 t CO_2-eq/capita).

Table 6.1. Sectorial CO_2-equivalent emissions

	Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	Energy	9,939.83	9,190.47	8,484.18	9,068.37	8,839.56	8,925.02	8,578.29	9,198.29	9,939.13	9,716.39	9,226.90	9,355.70	9,755.52
	Industry	889.29	908.89	957.78	831.36	716.56	793.28	819.71	910.30	891.78	742.43	885.70	929.02	784.05
	Agriculture	1,908.27	1,866.08	1,881.62	1,858.08	1,888.54	1,825.04	1,682.11	1,571.02	1,462.96	1,377.56	1,379.52	1,313.29	1,073.39
	LUCF	283.66	24.07	424.06	758.82	273.29	5.67	51.49	177.63	89.16	99.57	1,973.70	336.53	36.49
	Waste	786.29	794.97	806.08	808.37	753.66	778.67	785.13	822.21	827.12	828.38	844.23	836.38	840.59
	Total	**13,807.34**	**12,784.47**	**12,553.72**	**13,324.99**	**12,471.61**	**12,327.68**	**11,916.72**	**12,679.45**	**13,210.15**	**12,764.34**	**14,310.05**	**12,770.92**	**12,490.04**
[%]	Energy	71.99	71.89	67.58	68.06	70.88	72.40	71.99	72.54	75.24	76.12	64.48	73.26	78.11
	Industry	6.44	7.11	7.63	6.24	5.75	6.43	6.88	7.18	6.75	5.82	6.19	7.27	6.28
	Agriculture	13.82	14.60	14.99	13.94	15.14	14.80	14.12	12.39	11.07	10.79	9.64	10.28	8.59
	LUCF	2.05	0.19	3.38	5.69	2.19	0.05	0.43	1.40	0.67	0.78	13.79	2.64	0.29
	Waste	5.69	6.22	6.42	6.07	6.04	6.32	6.59	6.48	6.26	6.49	5.90	6.55	6.73
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 6.2. Contribution of CO_2, CH_4, N_2O, CO and HFC to CO_2-eq. emissions for all sectors

	Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	CO_2	10,545.33	9,598.08	9,321.21	10,048.55	9,290.20	9,213.08	8,928.41	9,793.79	10,408.98	10,055.09	11,283.60	9,959.41	10,059.08
	CH_4	1,732.78	1,703.43	1,747.30	1,775.03	1,697.21	1,695.97	1,666.20	1,675.40	1,630.70	1,628.35	1,741.23	1,656.67	1,621.23
	N_2O	1,253.22	1,218.64	1,221.40	1,199.10	1,224.80	1,173.38	1,057.27	970.94	936.79	845.36	959.99	813.94	570.40
	CO	276.01	264.33	263.80	302.31	259.40	245.25	264.85	239.32	233.68	235.54	300.03	220.44	208.62
	HFC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.20	120.47	30.71
	Total	**13,807.34**	**12,784.47**	**12,553.72**	**13,324.99**	**12,471.61**	**12,327.68**	**11,916.72**	**12,679.45**	**13,210.15**	**12,764.34**	**14,310.05**	**12,770.92**	**12,490.04**
[%]	CO_2	76.37	75.08	74.25	75.41	74.49	74.73	74.92	77.24	78.80	78.77	78.85	77.99	80.54
	CH_4	12.55	13.32	13.92	13.32	13.61	13.76	13.98	13.21	12.34	12.76	12.17	12.97	12.98
	N_2O	9.08	9.53	9.73	9.00	9.82	9.52	8.87	7.66	7.09	6.62	6.71	6.37	4.57
	CO	2.00	2.07	2.10	2.27	2.08	1.99	2.22	1.89	1.77	1.85	2.10	1.73	1.67
	HFC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.94	0.25
	Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

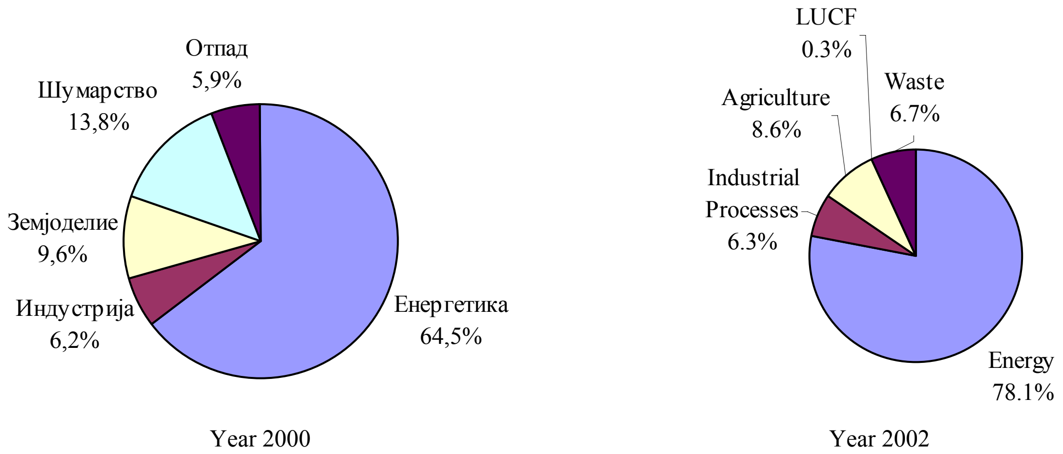

Figure 6.1. Contribution of individual sectors to total CO_2-eq emissions

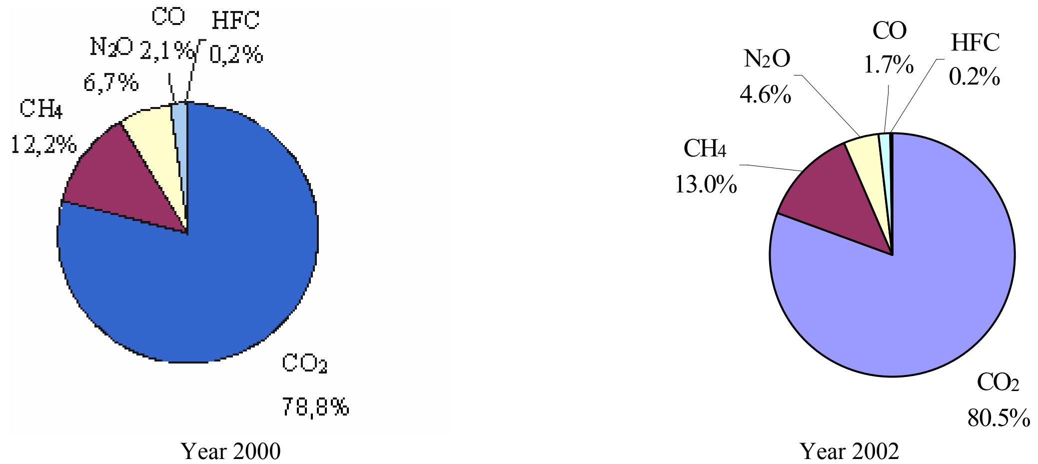

Figure 6.2. Contribution of individual GHGs to total CO_2-eq emissions

Table 6.3. Emissions per capita (approximate values)

Country	t CO_2-eq/capita
Australia	23.68
United States	22.82
Canada	22.00
Czech Republic	14.44
Russia	14.08
Germany	13.35
United Kingdom	11.69
Bulgaria	10.75
Japan	10.45
Greece	10.27
Slovakia	9.95
Slovenia	9.66
France	9.44
Italy	9.09
Romania	7.92
Hungary	7.62
Macedonia	6.18
Croatia	4.94

Source: International Carbon Bank & Exchange
(http://www.icbe.com/CarbonDatabase/CO2bypopulation.asp)

7. Key Source Analysis

Following the Good Practice Guidance, the national key source categories for each inventory should be identified in a systematic and objective manner by performing a quantitative analysis of the relationships between the level and the trend of each source category's emissions and total national emissions.

When using the Tier 1 approach, key source categories are identified using a predetermined cumulative emissions threshold of 95% of the total national emissions. When the national inventory estimates are available for several years as in the Macedonian inventory, it is a good practice to assess the contribution of each source category to both the level and trend of the national inventory. This was done for the period 1990-2002 using emissions estimates from previous chapters in this report considering 45 sources categories from all sectors.

Table 7.1 summarises the results of the analysis, presenting the Key Source Categories. The table lists all the source categories which appeared to be a key source at least in one year of the period 1990-2002.

In the last two columns of Table 7.1 we present the level of each key source category for the base year (2000) and for the year 2002. Since in the base year there were enormous forest fires which contributed with staggering 12% of the total emissions and distorted the usual pattern of key source categories, we decided to draw conclusions about the key sources having in mind the emission levels for the last year in the inventory. In addition, it is important to say that the emission levels for all categories are more or less the same for all other years except for the base year.

From the Table 7.1 it is obvious that the more important key source in Macedonia is the Energy Industry, which consists practically of GHG emissions from the lignite fired power plants. This key source alone contributes with about 50% in the total emissions. There is one more important key source from the Energy sector: the Road Transport with 7.4%. It is interesting to note that in some years (such is the case in 2002) the subsector "Others" contributes significantly and may appear very important. This is probably due to the practice in the Energy Balance, when in some years certain fuel consumption was not properly counted in the subsectors where it was really consumed.

The first by size non-energy key source is the Solid Waste Disposal on Land with 6%, followed by two Agricultural key sources: Enteric Fermentation with 4.4% and Agricultural Soils with 2.9%. In the Sector of Industrial Processes the most important key source is the

Cement Production with 2.9% which has the same level of intensity as the Energy subsector Manufacturing Industries and Construction. The rest of the key sources are with emission levels below 1%, except for the Fugitive Emissions from lignite mining and Civil Aviation which are slightly higher.

Table 7.1. Key Source Analysis – Summuary Results

No.	Source category	Gas	Number of years being a key cource	Level (%) in 2000	Level (%) in 2002
1	1.1.1. Energy Industries - CO2 from Oil	CO_2	13	5.607	4.507
2	1.1.2. Energy Industries - CO2 from Coal	CO_2	13	41.466	46.835
3	1.2.1. Manufacturing Industries and Construction - CO2	CO_2	13	3.320	2.900
4	1.3.3. Road Transportation - CO2	CO_2	13	6.711	7.448
5	1.5.1. Residential - CO2	CO_2	13	0.855	1.040
6	1.8.1. Fugitive Emissions - Coal	CH_4	13	1.108	1.281
7	2.1.1. Cement Production	CO_2	13	2.791	2.857
8	2.3.2. Ferroalloys Production	CO_2	13	1.320	0.904
9	3.1. Enteric Fermentation	CH_4	13	3.910	4.367
10	3.4. Agricultural Soils	N_2O	13	4.569	2.945
11	5.1. Solid Waste Disposal on Land	CH_4	13	5.240	5.994
12	1.6.1. Agriculture / Forestry / Fishing - CO2	CO_2	12	0.910	0.475
13	3.2.2. Manure Management - N2O	N_2O	12	0.774	0.867
14	1.5.2. Residential - Non-CO2	CO_2-eq.	11	0.840	0.746
15	4.1.1. Forest and Grass Land Conversion - CO2	CO_2	7	11.963	0.253
16	2.3.3. Zinc Production	CO_2	6	0.837	0.893
17	1.3.4. Road Transportation - Non-CO2	CO_2-eq.	6	0.674	0.704
18	1.7.1. Other - CO2	CO_2	5	1.100	9.683
19	1.3.1. Civil Aviation - CO2	CO_2	2	0.610	1.112
20	1.1.3. Energy Industries - CO2 from Gas	CO_2	2	0.762	0.789
21	4.1.2. Forest and Grass Land Conversion - Non-CO2	CO_2-eq.	1	1.829	0.039
22	6. HFC	CO_2-eq.	1	0.176	0.246

Identification of national key source categories is important because the resources available for preparing inventories are finite and their use should be prioritised. It is essential that estimates be prepared for all source categories, in order to ensure completeness. As far as possible, key source categories should receive special consideration in terms of three important inventory aspects:

- Additional attention has to be focused on key source categories with respect to the methodological choice. For many source categories, higher tier (i.e. Tier 2) methods are suggested, although this is not always possible;
- It is good practice that key source categories receive additional attention with respect to quality assurance and quality control (QA/QC);
- Definition of mitigation measures for GHG abatement.

8. Estimating Uncertainties by Using the Monte Carlo Analysis

The principle of the Monte Carlo analysis (which is the Tier 2 method for uncertainties estimation) is to select random values of emission factor and activity data from within their individual probability density functions, and to calculate the corresponding emission values. This procedure is repeated many times, using a computer, and the results of each calculation run build up the overall emission probability density function. The Monte Carlo analysis can be performed at the source category level, for aggregations of source categories or for the inventory as a whole.

The Monte Carlo analysis can deal with probability density functions of any physically possible shape and width, can handle varying degrees of correlation (both in time and between source categories) and can deal with more complex models for emission estimation.

Like all methods, the Monte Carlo analysis only provides satisfactory results if it is properly implemented. This requires the analyst to have scientific and technical understanding of the inventory and the Monte Carlo method itself. Of course, the results will only be valid to the extent that the input data, including any expert judgments, are sound.

Since all the above requirements for a successful implementation of the Monte Carlo analysis are not met for all source categories within the Macedonian inventory of GHG, in this section we would like to show one possible scenario for the uncertainties estimation for the Sectoral Approach of the Energy Sector.

We have applied the software package Simulación 4.0 (http://www.cema.edu.ar/~jvarela), which was fully developed in VBA (Visual Basic for Applications) and it is compatible with Excel 97 and above. It has been created in order to bring a flexible simulation tool, easy to be used.

We have selected the Normal distribution function, for which only a mean value and standard deviation for each variable has to be defined. The mean value is practically the value of each activity data, conversion and emission factors as they were found in the corresponding data sources (Energy Balance, Reference Manual and the Workbook). On the other hand, the estimation of the standard deviation, i.e. the certainty (accuracy) of the mean value is much bigger problem. Since no data on the subject exists we have simply set the values of 10% for the activity data and 5% for conversion and emission factors.

The reported emissions for the Sectoral Approach for the Energy Sector (see Chapter 1) for the base year (2000) are presented in Table 8.1. After 20,000 Monte Carlo simulations, the maximum, minimum and mean value, as well as the standard deviation for the emission for each subsector and for the whole Energy Sector have been calculated. The results are presented in Table 8.2. The last column of Table 8.2, the ratio of the standard deviation and the mean value may be practically interpreted as uncertainty of the emission estimated for the subcestors within the Sectoral Approach and for the whole Energy Sector for the year 2000.

Table 8.1. CO_2 emissions from the Energy Sector for the year 2000 – Sectoral Approach

Subsector	**(kt)**
Energy Industries	6,845.23
Manufacturing Industries And Construction	475.04
Transport	1,060.80
Residential Sector	122.38
Agriculture / Forestry / Fishing	130.19
Other	157.36
Total	**8,791.00**

Table 8.2. Summary Results of the Monte Carlo simulation of the CO_2 emissions from the Energy Sector for the year 2000 – Sectoral Approach

Subsector	**Maximum**	**Minimum**	**Mean**	**Std. Dev.**	**Dev./Mean**
Energy Industries	9,921.42	4,104.27	6,842.49	735.76	10.75%
Manufacturing Industries And Construction	651.85	333.82	474.96	37.04	7.80%
Transport	1,406.76	738.24	1,060.85	83.58	7.88%
Residential Sector	165.38	87.05	122.46	10.60	8.65%
Agriculture / Forestry / Fishing	192.54	87.29	130.30	12.05	9.25%
Other	208.63	107.05	157.31	13.13	8.35%
Total	**11,774.20**	**6,070.84**	**8,788.37**	**742.36**	**8.45%**

Under the Tier 1 method, the uncertainties in the source categories can be combined using analytical formulas to provide uncertainty estimates for the entire inventory in any year. There are two convenient rules for combining uncorrelated uncertainties under addition and multiplication which are practically the only mathematical operation employed in the emissions calculation. In order to confirm the results of the uncertainty calculation with the Monte Carlo simulation, we have calculated the uncertainties with the Tier 1 method for the Energy Industries.

The calculated total uncertainty of 10.70% for the Energy Industries is very close to the value obtained by the Monte Carlo simulation, which is 10.75%. The total uncertainty for the whole Energy sector calculated by the Tier 1 approach is 8.44% which is practically the same as the value obtained by the Monte Carlo simulation. All this confirms that the simulation was properly carried out.

9. Conclusions

The GHG Inventory process for the Second National Communication on Climate Change incorporates many of the good practice elements defined in IPCC Good Practice Guidance and Uncertainty Management. The inventory has been extended and now it includes the years 1990-2002, and besides the main GHGs (CO_2, CH_4 and N_2O), information on all non-direct GHGs (HFCs, PFCs and SF6 as well as CO, NOx, SOx and NMVOCs) has been added. In addition, the time series for the period 1990-1998 have been recalculated.

The input data have been revised taking into consideration data gaps and areas needing improvement. Most of the data gaps have been overcome by appropriately developed methods. This resulted in a more reliable time series for the national GHG Inventories for the period 1990-2002, complete and consistent Excel database appended by the full documentation of activity data and emission factors for the year 2000.

The total CO_2-eq emissions in the year 2000 amounted to 14,310.05 kt, which results in 7.06 t CO_2-eq/capita.

The national key source categories have been identified leading to a conclusion that the most important are: Energy Industries (51.3%), Road Transport (7.4%), Solid Waste Disposal on Land (6%), Enteric Fermentation (4.4%), Agricultural Soils (2.9%), Cement Production (2.9%) and Manufacturing Industries and Construction (2.9%). In future, the key source categories should receive special consideration with respect to the methodological choice for GHG emission calculation, as well as definition of mitigation measures for GHG abatement.

Recommendations for future work regarding the preparation of subsequent GHG inventories are given in all sectors. These recommendations are mainly focused on the possible application of the Tier 2 methods and revision/development of conversion and emission factors for some crucial areas.

Annex

Use of Organic Solvents and Other Compounds

For the purpose of the Second National Communication on Greenhouse Gases an assessment has been made of the consumption of solvents and other compounds that release VOC for the period of 1997-2002. Due to lack of data, this chapter has not been covered in the First National Communication.

The Revised 1996 IPCC Guidelines for the National Greenhouse Gas Inventories were taken into consideration in the first place. However, these only direct to other sources such as the CORINAIR and therefore the CORINAIR methodology has been involved in the assessment process.

No data have been found so far on consumption of paints other than the industrial consumption. However, having in mind that the average annual consumption of paint per capita in Europe is about 4.5 kg and that no car industry, which is the biggest consumer of paints, exists in Macedonia, one can assume that the annual consumption of paints per capita in Macedonia is about 3 kg.

An emission factor of 1 has been used for all organic solvents and other volatile organic compounds, while the emissions of the NMVOC from paints have been calculated using an emission factor of 0.5 according to the CORINAIR Guidelines.

The emissions of the NMVOC from the use of organic solvents and similar compounds over the reported period are summarized in Table 1. Figure 1 is a graphical presentation of the figures in table 1.

Table 1. Paints and solvents consumed and emissions there from in the period 1997-2002 (kt)

Year	Consumption	Emission
1997	14.993	11.997
1998	15.540	12.528
1999	14.848	11.823
2000	14.331	11.292
2001	13.831	10.779
2002	13.071	10.037

Apart from the organic paints variety of organic solvents have been used among which trichlorethylene, ethyleneglicol, tholuene, xylene, sulphoderivatives and ethyl alcohol make over 90% of the consumption. The relative shares of these materials and compounds are presented in figure 2.

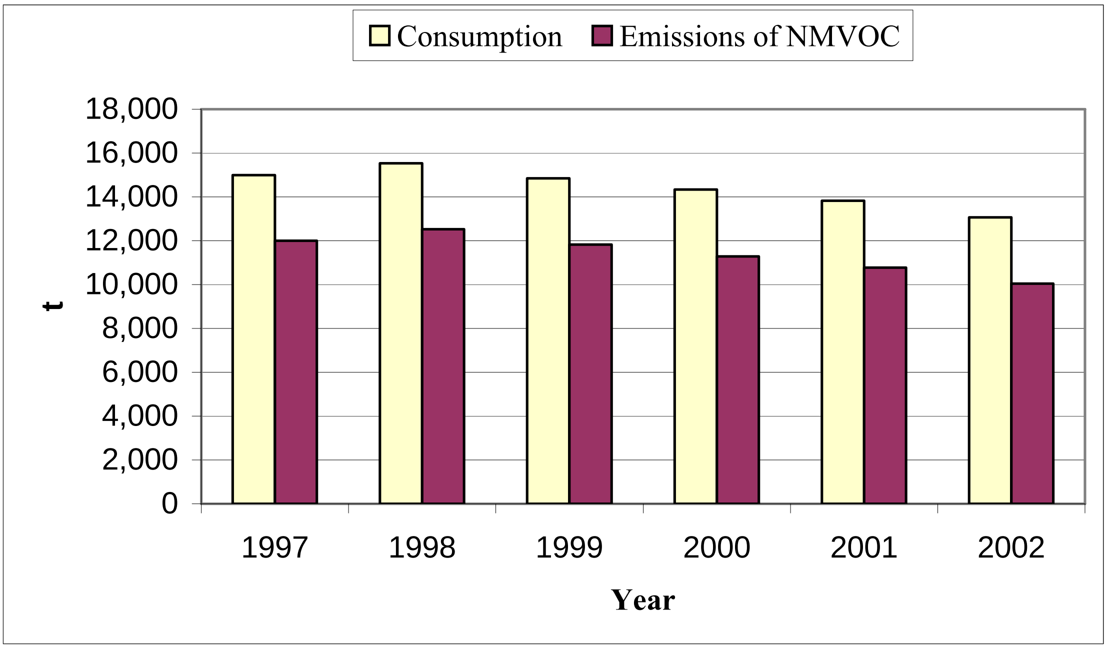

Figure 1. Consumption of paints, solvents and other organic materials and emissions of NMVOC there from in the period 1997-2002

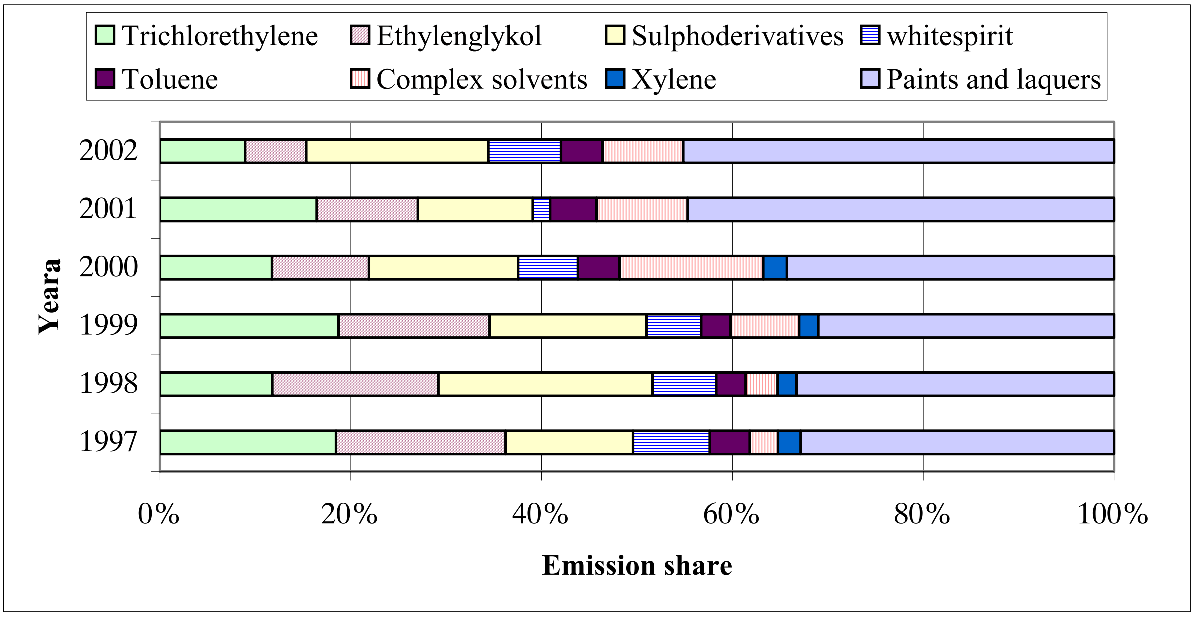

Figure 2. Consumption of paints and other organic materials in the period 1997-2002

The next inventory can be improved by refining the list of compounds, improving the knowledge of the pattern of consumption, including the emission abatement systems in the process of assessment and precisely following the IPCC guidelines once they are established.

Volatile organic compounds are inevitably released. Both process integrated and end of pipe measures are required in order to reduce the NMVOC emissions into the atmosphere. Process integrated measures should be focused on substituting the use of solvents wherever this is possible. Where substitution is not possible, regeneration and onsite recycling are strongly advised.

End of pipe measures are equally important even if a process integrated measure has been in place. The latter can only, although significantly, reduce the size and operating costs of an end of pipe measure.

In very few installations in Macedonia either of the measures is in place. Most of the car painting shops, dry cleaners or other installations including big ones such as coil dieing, electroplating etc. have no VOC abatement equipment.