CZECH HYDROMETEOROLOGICAL INSTITUTE

Section of the Director - *Department of Climate Change*
Air Protection Section - *Department of Emissions and Sources*

NATIONAL GREENHOUSE GAS EMISSION INVENTORY REPORT OF THE CZECH REPUBLIC

(REPORTED INVENTORY 2001)

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Content

1. Introduction

Annual monitoring of greenhouse emissions and sinks is one of the obligations coming from the *UN Framework Convention on Climate Change*. The first inventory study in the Czech Republic for 1990 was prepared in 1994 by SEVEn [1], and further studies concerned with the period between 1990 and the present were prepared after 1995 by the *Czech Hydrometeorological Institute* [2-8]. Following the authorization given by the *Ministry of the Environment*, the results of these studies were submitted in the prescribed format to the *Secretariat of the Framework Convention*, as an official national information, and simultaneously also formed the basis for the Second and Third National Communications [9, 10]. At the present time, CHMI prepares GHG emission inventories as part of its obligations as prescribed by its founder (MoE CR).

This study was carried out to prepare GHG emission inventory in the Czech Republic for the year 2001 in relation to the preceding period, especially to the reference year 1990. The greatest attention is focused on greenhouse gases that are subject to the *Kyoto Protocol* - CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. In addition, the precursors of greenhouse gases and aerosols (NO_X, CO, NMVOCs, SO_2) are also monitored. Similar to previous years, inventories of emissions and removals of greenhouse gases were prepared according to the IPCC methodology [11, 12]; its basic principles, latest developments and relation to the *Convention* and *Kyoto Protocol* will be described in Chapter 2, where a description will also be given of how this general methodology is applied under national conditions.

The division into chapters in this National Inventory Report corresponds to the categories of sources according to the IPCC methodology, i.e. energy production, the use of solvents, agriculture, forest management and wastes, and is connected with the classification used in previous years. In view of the extent and importance of emissions from the energy industry, description of this category was divided into two chapters (combustion of fuel and fugitive sources). Emissions of substances with increased radiation absorption effect (HFCs, PFCs and SF_6) are described in the separate chapter. As a consequence of extension of the methodical requirements and conversion into the *Common Reporting Format* (CRF), the structure of the inventory reports has undergone significant changes since the inventory for 1999, with increased emphasis placed on *key sources* [12]. The last chapter, Chapter 11 devoted to an overall summary of the results, discussion of the determined current emission trends and basic comparison with previous studies.

The final tables for the individual Sectoral Reports and the Summary Tables, describing GHG emissions in the individual source categories, were prepared in the CRF format and they are given in special Annex of Tables. The Sectoral Report gives data for 2001. The Summary and Trend Tables give data for 1990, 1994 and 1996-2001.

The inventory was prepared under the cooperation of experts from CHMI (P. Fott - Chapters 2, 3, 5, 7, 9, 10, J. Pretel and D. Vácha - Chapters 1, 8, 10 and 11) and from KONEKO Marketing Ltd. (J. Bláha - Chapter 3, V. Neužil - Chapters 4, 5, 6). These experts would also like to thank other consultants and expert teams, who provided basic input for preparation of the national GHG inventory within the required deadline. In particular, significant contributions have been given by V. Henžlík (ÚHÚL, Brandýs n/L), M. Havránek (COŽP UK), B. Bernauer, M. Markvart and J. Zábranská (VŠCHT Prague), V. Řeháček and L. Michálek.

Presented English version of NIR should be seen as a part of the regular data submission 2003 to the UNFCCC, which encompasses two data sets in CRF format. One set contains the data for 2001, while the second corresponds to the data for 1994, which was converted into CRF and was partly revised last year in a similar way as for the reference year 1990. At the present time, data for 1990, 1994, 1998, 1999, 2000 and 2001 are stored in the CRF format. The data for 1996 and 1997 are available in such format, which allows conversion to CRF format without any huge difficulties. In addition, we are planning conversion of data to CRF for 1992 and 1996 in next year.

The CRF data sets for 2001 also contain trend tables, which, however, contain only the values for 1990, 1994 and for 1996 - 2001. Data for 1991 - 1993 and 1995 are available, but they are not available in entirely consistent structure. It is necessary to complete recalculation of N_2O from Category 1A, refine the calculations for methane from industrial processes and energy production and complete some minor corrections. From the long-term perspective, it will be necessary to carry out complete revision of CH_4 emissions from agriculture and CO_2 removals from the LUCF category.

The preliminary CRF data set for 2001 (including the trend tables) was also provided to EEA (*European Environmental Agency*) in December of 2002 through the EIONET system. The final version of CRF is submitted simultaneously to EEA and UNFCCC. Thus, amongst other, the Czech Republic is in compliance with relevant obligations towards EEA under Council Decision 93/389/EEC as amended by Decision 99/296/EC for monitoring mechanisms of Community GHG emissions.

References

1. Tichý M., Voráčková Z., Dvořák P.: *Inventory of greenhouse gases in the Czech Republic in 1990*, SEVEn, Prague 1995.

2. Fott P., Bláha J., Pecka K.: *Inventories of greenhouse gasesin 1990-1993*, CHMI, "Global Climate Change" Project , Environmental Project No. 49/14/1/95, Prague 1995. (in Czech)

3. Fott P., Pretel J., Bláha J., Pecka K., Rábl V.: *Inventories of greenhouse gases in the Czech Republic in 1994 and 1995*, CHMI, "Global Climate Change II" Project , Environmental Project No. 310/1/96, Prague 1996. (in Czech)

4. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1996*, CHMI, "Global Climate Change III" Project , Environmental Project No. 310/1/97, Prague 1997. (in Czech)

5. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1997*, CHMI, "Global Climate Change IV" Project , Environmental Project No. 310/2/98, Prague 1998. (in Czech)

6. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1998*, CHMI, Prague 1999.

7. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1999*, CHMI, Prague 2000

8. Fott P., Pretel J., Bláha J., Neužil V.: National GHG Inventory Report of the Czech Republic (NIR), last year 2000, CHMI, Prague 2002

9. *The Czech Republic's Second National Communication of the Czech Republic on the UN Framework Convention on Climate Change, ME CR*, Prague 1997.

10. *The Czech Republic's Third National Communication of the Czech Republic on the UN Framework Convention on Climate Change, ME CR*, Prague 2001.

11. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC 1997.

12. Good Practice Guidance and Uncertainty Management in National GHG Inventories, IPCC 2000.

2. Inventory Methodology

2.1 Overview of the IPCC Methodology

The IPCC methodology has been prepared for the purpose to compile national inventories of anthropogenic GHG emissions and removals. Its first version was published in 1995 [1]. However, it was reviewed soon afterwards, so that the second version has been in use since 1997 [2].

Methodology is related to greenhouse gases with direct radiation absorption effect (CO_2, CH_4, N_2O, substances with increased radiation absorption effect containing fluorine HFCs, PFCs and SF_6, precursors of tropospheric ozone NO_X, NMVOCs, CO, and aerosol precursor SO_2). It highlights CO_2 emissions as the most important greenhouse gas. The only anthropogenic sources according to the IPCC methodology is fossil fuels combustion and, to some extent, also cement production, possibly also limestone and other carbonate minerals decomposition (e.g. melting of glass, liming of soil, lime-based sulfur removal, etc.), unless subsequent sinks compensate these.

The combustion of fossil fuels in stationary and mobile sources usually constitutes the best-known group of sources in most countries. Two IPCC methods are prescribed for the determination of CO_2 emissions from fuel combustion; independent approaches are based to a certain degree on the national energy balance. A simpler procedure (**Reference Approach)**, was described in [1] and basically determines the total amount of burned carbon on the basis of the balance calculation of apparent consumption of individual types of fuel (e.g. hard coal, petroleum, petrol, natural gas) for which the inventory is prepared (i.e. mining + imports - exports - change in stocks). This information is expressed in energy units (TJ) in the energy balance. The necessary emission factors for carbon (t C/TJ) for the individual kinds of fuel are listed in the methodical materials and are sufficiently accurate.

The second method (**Sectoral Approach)** is described more precisely in new version of the *IPCC Guidelines* [2] and it is based on the actual fuel consumption in individual categories (e.g. energy production, industry, transportation). The calculation using these two methods requires different items in the energy balance. The Reference Approach is based on primary sources, while the Sectoral Approach is based on transformation processes and final consumption. Both methods also take into account that a smaller part of the fuel is utilized for purposes other than energy production (e.g. lubricating oils, asphalt). For other fuels, it is assumed that almost all the carbon is burned to form carbon dioxide and a small correction is made for unburned carbon. The Reference Approach is very transparent and thus is used especially for control purposes. On the other hand, it does not permit determination of source category of in which the emissions of carbon dioxide are generated and thus the Sectoral Approach has tended to be preferred recently. However, sufficiently reliable energy statistics are required for good quality inventories. The difference in the results for carbon dioxide emissions for the two methods should not exceed 2%.

Another source, or rather sink of CO_2, is related to Land Use Change and Forestry and it is associated, in particular, with felling or planting forests; the amount of carbon contained in felled trees is considered to correspond to emissions and, to the contrary, the amount of carbon contained in growing wood is considered as a sink. In this approach, any other CO_2

emissions formed, e.g., in burning or aerobic decay of wood or other biomass is not included in the overall emission balance.

Due to character of the most important CH_4 and N_2O sources, like coal mining, animal breeding, landfills and wastewater handling (CH_4), agricultural soils, management of animal waste, production of nitric acid, fluid-bed and local combustion, automobiles with catalyzers (N_2O), the most accurate method to determine emissions (e.g. continuous direct measurement) can be used only exceptionally. Therefore, calculations are based on monitoring of the relevant statistical indicators (coal mining, number of head of farm animals, amount of nitric acid produced, amount of nitrogenous fertilizers employed, etc.) and application of relevant emission factors is a part of emission calculations. Depending on the complexity of the calculation and types of emission factors used (generally recommended - *default*, country-specific, site-specific and technology-specific), the approaches described in the IPCC methodology are separated into three tiers.

The Tier 1 is typically characterized by simpler calculations, based on the basic statistical indicators and on the use of generally recommended emission factors of global or continental applicability. These emission factors are usually tabulated directly in methodical manuals [1-3].

The Tier 2 is based on sophisticated calculation and usually requires more detailed and less accessible statistical data. The emission factors (country-specific or technology-specific) are usually derived using calculations based on more complex studies and better knowledge of the source. Even in these cases, it is sometimes possible to find the necessary parameters for the calculation in ref. [2] or [3]. Procedures in the Tier 3 are usually considered to consist in procedures based on the results of direct measurements carried out under local conditions (site-specific and technology-specific emission factors).

Apparently, procedures in higher tiers should be more accurate and should better reflect the reality. However, they are more demanding in all aspects, and especially they are more expensive. Nonetheless, the determination of emissions according to a procedure in the Tier 1 should always be carried out at least for control, because of its higher transparency.

All GHG emissions can be also expressed in terms of total (or aggregated) values, which are calculated as a sum of the emissions of the individual gases multiplied by Global Warming Potential values (GWP). GWP correspond to the factor by which the given gas is more effective in absorption of terrestrial radiation than CO_2 (1 for CO_2, 21 for CH_4 and 310 for N_2O). Total amount of F-gases is relatively small compared to CO_2, CH_4 and N_2O; nevertheless their GWP values are larger by 2-4 orders of magnitude. So, total aggregated emissions to be reduced according to the *Kyoto Protocol* are expressed as the equivalent amount of CO_2 with the same radiation absorption effect as the sum of the individual gases.

2.2 Good Practice Guidance

Increased compliance requirements related to the *Kyoto Protocol* were basis for further and revision and improvement of IPCC methodology [2] to assure higher level of inventory quality and adequate reduction of inventory uncertainties. Therefore, the new methodological handbook [3] was prepared by the IPCC, entitled as *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (in following text it will be referred as the *Good Practice Guidance*. This methodical handbook is understand as a supplement to the revised *IPCC Guidelines* [2]. Its main aim is to assist Parties in preparing their inventories to assure that emission estimates are neither overestimated nor underestimated (wherever possible), and uncertainty in determining of emissions is reduced as much as possible.

Implementation of *Good Practice Guidance* in preparation of national inventory improves its transparency, consistency and completeness and it is good basis for an evaluation of levels and trends in uncertainties, verifiability (QC/QA mechanisms) and inventory comparison with other Parties.

Good Practice Guidance are divided into two groups:

- **sectoral aspects**, reflecting the specific features of the individual categories of sources,

- **general methodological aspects**, related mainly to determining uncertainties, choice of optimum strategy and ensuring adequate control mechanisms.

The **sectoral aspects** consist mainly of finding an unambiguous algorithm that takes into account the local conditions in given category to the maximum possible degree in selecting the method or tier, optimum approach in choosing emission factors and inclusion of all emission sources/sinks, ensuring the consistency of time series and determining the uncertainty.

In the framework of the *Good Practice Guidance*, rules have also been created for reporting results and documenting procedures in the given category and also enabling effective control and revision of inventories both by the preparing team - **QC (Quality Control)**, and by an independent audit - **QA (Quality Assurance)**.

In relation to **general methodological aspects**, mention should be made particularly of quantification of uncertainty in the individual year and in the overall trend. Simultaneously, consideration is given to cases of inaccuracies in the individual categories of sources, which is described either by the statistical scattering or at least on the basis of an expert estimates. The uncertainty in the total emissions or its trend can be determined in the Tier 1 using the method of error propagation, based on mathematical statistical relationships for calculation of the scattering of the sum or product from the corresponding scatters of the individual terms. Model methods of the Monte-Carlo type are more sophisticated and can be used for the Tier 2.

From a practical viewpoint, identification of *key sources* is of great importance. These sources contribute to a decisive degree to the total amount of emissions or to its uncertainty, both in the individual year and in terms of trends. Considerably more attention should be paid to *key sources* and their categories, compared to the remaining sources or categories. This means that, where possible, more sophisticated procedures at a higher tier should be used for determining emissions from *key sources*, using site-specific or at least national emission factor values. However, this is often not possible in the absence of expenditure of financial means required to ensure carrying out suitable studies and the relevant measurements. Any means employed to improve the quality of the inventory should be expended in the most effective manner possible and should be preferentially oriented to *key sources*.

One of the most important *Good Practice* issues consists in ensuring **consistent time series**. In order to achieve this goal, it is necessary to ensure that the entire time series is determined in a methodologically consistent manner. In case of revision of the methodology and its further development, it is sometimes necessary to recalculate the values for previous years if the emission values for these years were determined using an older, obsolete version.

Recalculation must sometimes also be carried out when an error is found in earlier calculations or in the use of an unsuitable method.

2.3 Implementation of Good Practice Guidance into national inventory

The Czech national inventory is generally based on the methodology according to [2]. Results determined by [1] were retained if no methodological change was involved, or had already been recalculated (e.g. CH_4 emissions from coal mining) or are recalculated here (e.g. N_2O emissions, CH_4 emissions from waste). In fact, the latter two revisions reflect *Good Practice Guidance* (recalculation of N_2O emissions for the years 1991 – 1993 and 1995 has not yet been completed).

The GHG emission inventories for 1999 and 2001 were carried out according to the ongoing introduction of *Good Practice Guidance*. Due to great extent of the relevant methodical approaches, this process will continue over the next two years. Attention in this inventory was focused particularly on identification of *key sources,* which will be targeted throughout the entire process. Emphasis is also placed on consistency of the time series.

On the other hand, in preparing this inventory, somewhat less attention was paid to emissions of the precursors NO_X, CO, NMVOCs and SO_2, which are covered primarily by *Convention on Long-Range Transboundary Air Pollution* (CLRTAP) and are not directly related to the Kyoto Protocol. Their inventories are compiled for the purposes of CLRTAP by NFR (*New Format of Reporting*) by another team at CHMI. Since 2001, emissions of precursors in the GHG inventory (CRF) have been fully taken over and transferred from NFR.

It is also necessary to point out that an appropriate counterpart to *Good Practice Guidance* is only now being prepared for the category Land Use Change and Forestry and should be completed by the IPCC later in 2003. At the present time, only the methodical instructions given in [2] have been employed.

As part of *Good Practice Guidance* implementation and as a response to review processes performed by UNFCCC, it was decided to re-classify emissions from the production of iron and steel. To date, these emissions have been treated under sub-category 1A2 (to be compatible with the *Reference Approach*); starting with the year 2001, these emissions are classified under 2C1 (Metal industry, Production of iron and steel). However, the corresponding recalculation of the whole time series since the reference year 1990 will not be carried out until next year.

Last year, uncertainty analysis through the preparation of calculating spreadsheets for the Tier 1 approach has been also commenced. The national inventory team believes that some preliminary results for the Czech inventory will be available at the time of the Submission2004.

2.4 Key sources

To reduce inventory uncertainty it is preferable to determine emissions from the individual sources in as rigorous a manner as possible, i.e. using methods in higher tiers, that, where feasible, take into account the local conditions and use to the maximum degree country-specific, site-specific and technology-specific emission factors. However, application of these methods is sometimes demanding, both financially and in terms of working capacity. However, these means should be used as purposefully as possible and should be oriented particularly towards those sources that contribute in a decisive manner to the overall uncertainty in determining total emissions. In [3], these sources or their categories are termed *key sources*. By definition, the term *key sources* also include the relevant greenhouse gas with direct radiation absorption effect.

The *Good Practice Guidance* provides two tiers of determining these *key sources*. *Key sources* by definition contribute to ninety percent of the overall uncertainty in a level (in emissions per year) or in a trend. The procedure in the Tier 2 follows from this definition, and requires thorough analysis of the uncertainty and use of sophisticated statistical procedures and evaluation of sources in terms of the appropriate characteristics. However, it is very difficult to obtain the necessary data for this approach and this information is not yet available on the national level.

The procedure of the Tier 1 according to [3] is based on the fact that ninety percent of the overall uncertainty in a level or in a trend is usually caused only by those sources whose contribution to total emissions does not exceed 95%. This procedure is illustrated in Tab. 2.1 (determined on the basis of the level of emissions, i.e., **level assessment**) and Tab. 2.2 (determined on the basis of trends, **trend assessment**). The sources or their categories, defined for these purposes in [3] are ordered, for level assessment, on the basis of decreasing contribution to total emissions (based on emissions for 2000). The *key sources* were considered to be those (denoted in bold) whose cumulative contribution is less than 95%. For trend assessment, a similar procedure is used; with the difference that here the decisive quantity is defined as the product of the relative contribution to the total emissions (determined in the previous case) and the absolute value of the relative deviation of the individual trends from the total trend [3].

On the basis of the emission level (Tab. 2.1), a total of 12 *key sources* were established (denoted in bold, where trend analysis (Tab. 2.2) led to inclusion of substances containing fluorine (HFCs, PFCs and SF_6) whose values increased, in contrast to the overall trend.

Due to limited capacity of the national inventory team, an update of key source determination has not yet been performed. Therefore, determination presented in NIR related to Submission 2002 remains unchanged in presented NIR. However, the national inventory team plans to carry out this desirable update during 2003 and to submit it as an appendix to presented NIR.

The inventory team has also commenced step-by step implementation of QA/QC procedures according to *Good Practice Guidance* (so far only on tier 1 level).

Tab. 2.1 Determining National Key Source Categories (*Tier 1 – Level assessment*)

	Gas	Emissions [Gg]	% of total	Cumulate [%]
Energy: Stationary Combustion - Solid (CO₂)	**CO₂**	85 143	57.7	57.7
Energy: Stationary Combustion - Gas (CO₂)	**CO₂**	17 884	12.1	69.8
Energy: Mobile Combustion - Road	**CO₂**	10 344	7.0	76.8
Energy: Stationary Combustion - Liquid (CO₂)	**CO₂**	9 909	6.7	83.5
Energy: Fugitive Emissions - Coal Mining (CH₄)	**CH₄**	5 019	3.4	86.9
Agriculture: Direct Emissions N₂O from Soils	**N₂O**	2 868	1.9	88.9
Industrial: Mineral Products - decarbonizing (CO₂)	**CO₂**	2 251	1.5	90.4
Agriculture: Indirect Emissions N2O from Agriculture	**N₂O**	1 863	1.3	91.7
Agriculture: Enteric Fermentation (CH₄)	**CH₄**	1 701	1.2	92.8
Waste: Landfills (CH₄)	**CH₄**	1 596	1.1	93.9
Energy: Mobile Combustion - Off Road incl. Waters	**CO₂**	1 461	1.0	94.9
Industrial: Nitric Acid (N₂O)	**N₂O**	1 128	0.8	95.7
Energy: Stationary Combustion	N2O	952	0.6	96.3
Industrial: Usage of New Gases	HFCs, ..	890	0.6	96.9
Waste + Solvent Use: Waste Incineration + SU	CO₂	692	0.5	97.4
Agriculture: Manure Management (CH₄)	CH₄	688	0.5	97.8
Energy: Fugitive Emissions - Oil and Gas (CH₄)	CH₄	604	0.4	98.3
Waste: Wastewater Handling	CH₄	578	0.4	98.6
Energy: Mobile Combustion - Road	N₂O	508	0.3	99.0
Energy: Mobile Combustion - Aircraft	CO₂	438	0.3	99.3
Agriculture: Manure Management (N₂O)	N₂O	422	0.3	99.6
Energy: Stationary Combustion	CH4	362	0.2	99.8
Waste: Wastewater Handling	N₂O	202	0.1	100.0
Energy: Mobile Combustion - Road	CH₄	40	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	N₂O	19	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	CH₄	5	0.0	100.0
Energy: Mobile Combustion - Aircraft	N₂O	3	0.0	100.0
Energy: Mobile Combustion - Aircraft	CH₄	2	0.0	100.0

Tab. 2.2 Determining National Key Source Categories (*Tier 1 – Trend assessment*)

	Gas	1990 [Gg]	2000 [Gg]	% of total	Trend [%]	Part [%]	Cum. [%]
Energy: Stationary Combustion - Solid (CO_2)	**CO_2**	124 441	85 143	57.7	9.2	32.8	32.8
Energy: Stationary Combustion - Gas (CO_2)	**CO_2**	12 933	17 884	12.1	7.0	25.2	57.9
Energy: Mobile Combustion - Road	**CO_2**	5 995	10 344	7.0	5.1	18.2	76.1
Energy: Stationary Combustion - Liquid (CO_2)	**CO_2**	14 407	9 909	6.7	1.0	3.6	79.7
Industrial: Usage of New Gases	**HFCs**	0	890	0.6	0.8	2.8	82.5
Energy: Fugitive Emissions - Coal Mining (CH_4)	**CH_4**	7 600	5 019	3.4	0.7	2.6	85.1
Agriculture: Enteric Fermentation (CH_4)	**CH_4**	3 271	1 701	1.2	0.7	2.6	87.7
Agriculture: Direct Emissions N_2O from Soils	**N_2O**	4 529	2 868	1.9	0.5	1.9	89.6
Energy: Stationary Combustion	**CH_4**	1 174	362	0.2	0.5	1.7	91.3
Agriculture: Indirect Emissions N_2O from Agricult.	**N_2O**	3 041	1 863	1.3	0.4	1.5	92.8
Energy: Mobile Combustion - Road	**N_2O**	71	508	0.3	0.4	1.4	94.2
Industrial: Mineral Products - decarbonizing (CO_2)	**CO_2**	3 380	2 251	1.5	0.3	1.1	95.3
Energy: Mobile Combustion - Off Road incl. Waters	CO_2	2 304	1 461	1.0	0.3	1.0	96.3
Waste + Solvent Use: Waste Incineration + SU	CO_2	530	692	0.5	0.3	0.9	97.2
Industrial: Nitric Acid (N_2O)	N_2O	1 125	1 128	0.8	0.2	0.8	98.0
Energy: Mobile Combustion - Aircraft	CO_2	699	438	0.3	0.1	0.3	98.3
Waste: Landfills (CH_4)	CH_4	1 957	1 596	1.1	0.1	0.3	98.6
Agriculture: Manure Management (CH_4)	CH_4	1 017	688	0.5	0.1	0.3	98.9
Agriculture: Manure Management (N_2O)	N_2O	663	422	0.3	0.1	0.3	99.2
Energy: Fugitive Emissions - Oil and Gas (CH_4)	CH_4	676	604	0.4	0.1	0.3	99.4
Energy: Stationary Combustion	N_2O	1 321	952	0.6	0.1	0.2	99.6
Waste: Wastewater Handling	CH_4	826	578	0.4	0.0	0.2	99.8
Waste: Wastewater Handling	N_2O	202	202	0.1	0.0	0.1	100.0
Energy: Mobile Combustion - Road	CH_4	59	40	0.0	0.0	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	CH_4	12	5	0.0	0.0	0.0	100.0
Energy: Mobile Combustion - Aircraft	N_2O	6	3	0.0	0.0	0.0	100.0
Energy: Mobile Combustion - Aircraft	CH_4	4	2	0.0	0.0	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	N_2O	25	19	0.0	0.0	0.0	100.0

References

1. *IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC 1995.

2. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC 1997.

3. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

3. Emissions from Combustion Processes (Category 1A)

Combustion processes included in category 1A make a decisive contribution to total emissions of greenhouse gases. Almost all emissions of carbon dioxide, with the exception of decomposition of carbonate materials, occurring, e.g., in cement production, are derived from the combustion of fossil fuels in stationary and mobile sources. The role of combustion facilities is apparent from Tab. 2.1, from which it can be seen that 5 of the 13 *key sources* considered correspond to the combustion of fossil fuels in category 1A and, of these, the first four most important contribute approx. 83% of total emissions.

Consequently, the greatest attention is paid in the *IPCC Guidelines* [1] to inventories of emissions from these processes. In relation to [4], a differentiated approach is employed in inventories of emissions of greenhouse gases. Emissions of direct greenhouse gases, i.e. CO_2, CH_4 and N_2O, are calculated on the basis of activity data and emission factors of the fuel combusted. The relevant emission data corresponding to individual source subcategories for NO_X, CO, NMVOC a SO_2 are transferred directly from NFR to CRF.

The results of the inventory, including the activity data, are submitted in the standard CRF format. For direct greenhouse gases, the consumption of fuels and "implied" emission factors are also given. However, for stationary sources, the fuel consumption is given in the CRF format in aggregated structure, i.e. as solid, liquid and gaseous fuels according to IPCC definition. In relation to the degree of elaboration of the calculation procedures to date, the required CRF tables could be filled out with an exception, when processing industry (1A2) is reported as a whole. The currently available energy production statistics do not provide the necessary activity data for division of this category into the individual branches of industry.

3.1 Carbon dioxide emissions

According to [4], carbon dioxide emissions encompass the following five *key sources* at the primary level:

- stationary combustion of solid fuels,
- stationary combustion of gaseous fuels,
- highway transportation,
- stationary combustion of liquid fuels,
- other transportation.

These *key sources* have a decisive effect on the uncertainty in the absolute levels and trends in CO_2 inventories.

According to [1], carbon dioxide emissions are recalculated in two ways:

1. The **Reference Approach**, i.e. on the basis of total domestic consumption of the individual fuels. This relatively simple method is based on the assumption that almost all the fuel consumed is burned in combustion processes in energy production. It does not require a large amount of input activity data and the basic values of the sources included in the national energy balance and some supplementary data are sufficient. It provides information only on total emissions without any further classification in the consumer sector. The emission factors are related to those kinds of fuel that enter domestic consumption at the level of sources, without regard to specific kinds of fuel burned in the consumer part of the energy balance. Thus, for liquid fuels, this means that the emissions are determined practically only on the basis of domestic petroleum consumption.

2. The **Sectoral Approach**. This method is considerably more demanding in relation to input data and requires information on fuel consumption according to kind in the individual consumer sectors. It has an advantage in the possibility of analyzing the structure of the origin of emissions. As the emission factors employed are specific for each kind of fuel burned, calculations using this method should be more exact. However, it follows from the discussion below that the differences in the overall results from the two methods are not very significant.

Reference Approach

The IPCC Reference Approach is based on determining carbon dioxide emissions from domestic consumption of individual fuels. **Domestic fuel consumption** is calculated in the usual manner as:

$$\text{extraction + imports - exports - change (increase) in stocks}$$

Extraction includes domestic extraction of petroleum, natural gas (of petroleum or coal origin) and hard and brown coal. The obtaining of other solid fuels, mostly wood for burning, is given in the calculation under the special item solid biomass. In this method, emissions from this fuel are not included in emissions from combustion processes, as they are calculated in the inventory in the forestry category. **Imports** of fuel include imports of natural gas, petroleum, individual liquid fuels, hard and brown coal, coke and briquettes. **Exports** and **changes in stocks** include similar items. The item **changes in stocks** also includes losses and balance differences that do not entail combustion processes and would distort the results.

Total national consumption is corrected by **subtracting non-energy consumption**. A substantial portion of non-energy consumption consists in non-energy consumption of petroleum (lubricating and special oils, asphalt and particularly petroleum raw materials used in the production of plastics, etc.). Non-energy products produced from hard coal in coke plants and from brown coal in the production of town gas and energy-production gas (fuel for steam-gas systems) are also important. Some of the intermediate products from the pyrolysis of petrochemical materials are also used directly as heating gases and oils and some of the final products (plastics) are also burned after use. In addition, most lubricating and special oils are finally used as heating oils or are burned during use (the lubricating oils of internal combustion motors). The currently used methodology does not respect this fact. The calculated emissions are by about 1% higher comparing to previous method.

The carbon content is calculated from the corrected domestic consumption of the individual fuels using emission factors and the emissions of carbon dioxide are then calculated by taking into account the efficiency of conversion of carbon in the combustion process. The emission

factors determining the carbon content in the individual fuels (in t C/TJ) are taken from the IPCC methodology, as are the recommended values of "oxidation factors" (correction for the unburned carbon residue).

Sectoral Approach

This method, which is based on the records of fuel consumption in the individual categories is elaborated in great detail in the IPCC methodology and, compared to the former version (to 1995), requires determination of the consumption of the individual kinds of fuel in all the consumption categories (and not only the basic groups, i.e. solid, liquid and gaseous fuels).

Determining fuel consumption

In relation to the current ability of Czech energy production statistics to determine the corresponding fuel consumption, combustion processes can be divided into only the following basic categories:

1A1 - Energy & Transformation Activities

Public electricity and heat production

Petroleum refining

Manufacture of solid fuels and other energy industries

1A2 - Manufacturing industries and construction (including industrial electricity and heat production)

1A3 - Transport

Civil aviation

Road transportation

Railway

Navigation

Gas and petroleum pipelines transportation

1A4 - Commercial / Institutional

1A5 - Residential

1A6 - Agriculture / Forestry

The consumption in international air transportation is included in the special category **International Bunkers**. Emissions from fuels in this category are not included in the total emissions in the territory of the state, but are summarized directly in global emissions.

The IPCC method does not specify inclusion of consumption in compression stations for the transit of natural gas in transit gas pipelines. While emissions from this consumption are generated in this country, consumption in compression stations is not part of the energy balance of this country and is affected only by external factors. As transit gas pipelines generally pass through several countries, there is a certain analogy with international air transport. However, CRF tables do not permit this approach and thus emissions from domestic and transit gas pipelines are included in a single item.

Similarly as for the reference method, emission factors, specifying the carbon content in the individual fuels (in t C/TJ) and relevant oxidation factors are taken from the IPCC methodology.

Compared with the Reference Approach, the results of the two methods are very similar and differences are below the precision levels of the input data. From this point of view, the two methods can be considered to be equivalent. The results of inventories carried out by the two procedures differ by less than 2 % for all time period (in accord with the CRF requirement);

the values for the last few years and a comparison are given in Tab. 3.1. In the inventory, the two procedures were employed in the structure described in the working manuals for the method [1] and [2], i.e. including the values of the emission factors of carbon and the standard means of correction for unburned residues.

Emphasis is placed on correct determination of the fraction of unburned (stored) carbon in non-energy use of fossil fuels. Calculation of this amount is based on the assumption that a certain part of the carbon contained in the non-energy material remains fixed for a long time and is not released as CO_2. The fraction of stored carbon in petrochemical materials and oils is standardly considered to equal 50% and, for tar, 75%. Practically one hundred percent fixation is assumed for asphalt.

Similarly, it is necessary to ensure that the carbon, converted to CO_2 in non-energy use, is calculated only once. Carbon dioxide formed in the production of hydrogen used mainly for subsequent synthesis of ammonia is a typical example. Under the conditions in this country, this process consists in gasification of masout using oxygen and steam, with subsequent catalytic conversion. To avoid double counting, the carbon in the masout was reported in the energy-production category (combustion in industry).

Tab. 3.1 Comparison of CO_2 emissions calculation from the fossil fuel combustion in 1990, 1994 and in 1996 - 2001

	1990	1994	1996	1997	1998	1999	2000	2001
Reference approach [Gg]	159 073	126 258	129 673	131 386	122 662	115 136	122 116	124 730
Sectoral approach [Gg]*)	160 080	127 116	129 380	133 837	124 392	117 159	124 420	124 770
Deviation [%]	0.6	0.7	0.2	1.8	1.4	1.7	1.9	0.0

*) Including the iron and steel industry that has been reported under 2C1 since 2001

The area of production of iron and steel is another difficult area from the standpoint of the potential for reporting CO_2 emissions in several categories. Here, the primary source of emissions is carbon contained in the coke used in blast furnaces in iron production. However, the actual emissions of carbon dioxide from metallurgical coke do not occur in the blast furnace, but in subsequent combustion of blast-furnace gas in energy production. To date, all CO_2 emissions from coke have been included in the energy category 1A2, including those from the metallurgical process itself (oxidation of carbon from pig iron during steel production). The calculation procedure is based on the amount of carbon in the coke as a reducing agent that is used in metallurgical processes. Beginning in the year 2001, the CO_2 emissions from the iron and steel industry are reported under 2C1 (Industrial processes) in accordance with the *Good Practice Guidance*. Recalculation for the whole time series will be performed in 2004.

Comparison with 1990 indicates a marked decrease in the level of emissions of carbon dioxide, corresponding to the decrease in the domestic consumption of primary fossil fuels. This is a consequence of the lower consumption of coal and its partial replacement by natural gas. Tab. 3.2 gives the decrease in this consumption over the past decade. There has been only a small decrease in the consumption of liquid fuels (with the exception of the sudden decrease at the beginning of the nineties), but there has been a marked change in the structure of consumption. In 1990, the fraction of heating oils in the consumption of liquid fuels equalled 37%, while this figure equalled only 12% in 2001. There was a substantial increase in consumption of natural gas.

Tab. 3.2 Total primary energy sources in 1990 and in 2001 [PJ]

	1990	2001	Decrease in consumption
Total primary energy supply	1 819.5	1 571.8	247.7
coal	1 252.7	887.3	365.4

The Sectoral Approach, in contrast to the Reference Approach, permits analysis of the structure of the source of the emissions. It is then possible to determine that there was a change in the sectoral structure of the origin of emissions of carbon dioxide in years 1990, 1994 and 1996 - 2001, as can be seen in Tab. 3.3. Comparison with previous years is not possible, as inventory calculations in period of 1990 to 1995 were carried out using a slightly different method [2] (the data for the years 1990 and 1994 were recently revised).

Tab. 3.3 Share of individual categories on the CO$_2$ emissions in 1990, 1994 and in 1996-2001[*)] [%]

	1990	1994	1996	1997	1998	1999	2000	2001
Energy Industry	37.0	43.8	44.7	44.2	47.2	45.9	48.4	48.4
Manufacturing industry	37.1	34.8	33.9	32.4	28.4	29.2	29.1	29.3
Transport	4.5	6.0	7.5	8.4	8.6	10.0	8.9	9.7
Commercial, services..	6.0	4.6	4.1	4.8	4.7	4.8	4.4	3.4
Residential	13.0	9.2	8.5	8.8	9.7	8.7	7.9	8.0
Agriculture	2.4	1.6	1.3	1.4	1.4	1.4	1.3	1.2

*) Including the iron and steel industry that has been reported under 2C1 since 2001

The fraction of emissions from the processing industry and households decreased as a consequence of the marked decrease in consumption, especially of coal. On the other hand, there was a significant increase in emissions from transport as a consequence of increasing consumption of liquid fuels in highway transport. There was a relative increase in the fraction of emissions from the energy-production industry because, for lower total emissions, the absolute values of emissions from energy-production in 2001 are practically at the same level as in 1990.

According to the *IPCC Guidelines* [1], emissions from international air transport are not reported as part of national emissions, but are reported separately, because they are summarized directly in global emissions. The calculation is based on the amount of fuel tanked into the aircraft in the particular country of origin. The contribution of the Czech Republic to international air transport varies around a value of 0.5 Mt CO$_2$ p.a.

3.2 Methane emissions

Methane emissions from fuel combustion from stationary and mobile sources do not constitute *key sources*. Relatively the largest contribution comes from fuel combustion in local heating units.

The means of determining methane emissions is similar in many respects to the method of the individual consumption categories for carbon dioxide emissions. The simplest level (Tier 1) [1] includes only summary fuel categories:

> coal-type solid fuels
> gaseous fuels
> liquid fuels
> wood fuel (biomass)
> charcoal
> other biomass.

Only the first four categories were filled with active data in the inventory. These data were aggregated directly from the connected working sheets for the calculation of carbon dioxide by the consumption sector method.

CH_4 emissions were calculated based on default emission factors recommended by *IPCC Guidelines* ([1], Part 3 - *Reference Manual*). In the process of calculation CH_4 emissions from transport category should be pointed out that individual fuel consumption in the given category is considered as activity data. This is related particularly to gasoline, diesel oil, jet kerosene, natural gas, and propane-butane (LPG) consumption.

3.3 Nitrous oxide emissions

Although N_2O emissions from combustion processes are not amongst *key sources* in the Czech Republic, these emissions from both stationary and mobile sources represent a somewhat more important contribution than that made by CH_4 emissions.

N_2O emissions were calculated by a similar method as CH_4 emissions, directly using the emission coefficients lying within the recommended intervals given in the revised *IPCC Guidelines* [1]. The emission factors for combustion from stationary sources were taken from [9]. This study provides a critical evaluation of two earlier national studies [3, 13] and compares them with the *default* values given in the *Reference Manual* [1]. The data lacking for the combustion of brown coal were taken from study [3]. It should be pointed out that the emission factors used are not contradictory to the values given in [1] and reflect the following facts:

- the emissions factors for combustion of pulverized coal in granulation furnaces have the smallest values,

- the values used for grate furnaces are only slightly higher,

- the emission factors for fluid-bed furnaces are highest, especially those for hard coal and lower relative furnace outputs (compared to nominal outputs), manifested in a lower temperature of combustion.

In calculation of N_2O emissions from mobile sources, the most important source according to [1] seems to be passenger automobile transport, especially passenger cars with catalyzers. The emissions factors for N_2O for vehicles with diesel motors and for vehicles with gasoline motors without catalyzers are not very high and were taken in the standard manner from the methodical instructions [1]. The situation is more complex for vehicles with gasoline motors equipped with three-way catalyzers. The method [1] gives three pairs of emission factors for passenger cars with catalyzers (for new and deactivated catalyzers). The value for a deactivated catalyzer is approximately three times that for a new catalyzer. In accord with the studies [1, 7], the pair of values recommended on the basis of Canadian research was selected because of the lack of domestic data; in addition, American and French coefficients are available in the new methodical instructions [1]. The arithmetic mean of the values for new and older used catalyzers was taken as the final emission factor for passenger cars with catalyzers.

The calculation was based on the consumption of petrol and diesel fuel by the main types of vehicles. Here, the consumption of petrol must be divided into the part burned in vehicles equipped with three-way catalyzers and other vehicles. The calculation was based on an estimate following from the study of the *Transport Research Centre* (CDV) prepared annually for *Ministry of the Environment*, estimating the fraction of gasoline-propelled vehicles equipped with three-way catalyzers. According to [10], in 2001, the fraction of petrol-propelled vehicles equipped with three-way catalyzers equalled 32%. Similar to

previous years, we assume that newer vehicles emit larger amounts and again express this by a coefficient of 1.5. The result of this calculation is that not quite 48% of petrol is burned in vehicles with catalyzers.

A partial increase in N_2O emissions can be expected in this category in connection with the growing fraction of vehicles equipped with three-way catalyzers, or the expected increase in the number of fluid-bed combustion units.

3.4 Total emissions from combustion - summary and QA/QC procedures

3.4.1 Activity data

Determination of the activity data on fuel consumption was based on the preliminary energy balance, prepared by KONEKO Marketing Ltd., on the basis of the material published to date by the *Czech Statistical Office* (CSO) and other organizations on trends in energy management in 2001. For these purposes, it is often necessary to use preliminary information, as CSO does not issue final data until the first quarter of the second year following the year in question (data for 2001 were be issued in 2003). The preliminary energy balance for 2001 was prepared using the method of the *International Energy Agency*. Such a balance permits filling of the basic categories of the IPCC method with activity data. At the time, when the preliminary balances are prepared, usually only basic data is available on extraction of fuels, imports, exports and production of the main energy commodities (petroleum, natural gas, electricity). In addition, detailed information is lacking on the imports and exports of the individual fuels, on changes in stocks and particularly almost all data on consumption.

Determination of the activity data for revision of 1994 was based on the total CSO balance for that year. While definitive data is given here, only information on the source part may be used without difficulties. However, data on energy consumption are not entirely sufficient for application of the *Sectoral method* even in the final energy balance.

Consequently, drawing up of the energy balance in the IEA (*International Energy Agency*) method from available data requires the use of a number of specialized procedures in both the source and especially in the consumption parts. In the source part, this is especially true of expression of production of heat in centralized systems, which includes only public sources in the IEA method and, for industrial sources, only that part sold to other entities. Drawing up the necessary categorization of the energy balance in the consumption part is connected with considerable difficulties.

In order to classify consumption in the transport category in the individual subcategories, a specialized model of the MAED transport type was employed. This is one of a series of models of the *International Atomic Energy Agency*. These models are used in predicting consumption of all kinds of energy in the entire national economy. The necessary data on the individual segments of transport cannot be obtained directly, as they are not monitored in this classification. For similar reasons, another specialized model, again of the MAED type, was used to determine energy consumption in the household category. In both cases, calculations for 2001 took into account the results of the statistical study "Energy consumption in households", carried out in 1997 by CSO on the basis of the PHARE/EUROSTAT method. All of categories 1A1 to 1A6 were filled with data on consumption of the individual solid, liquid and gaseous fuels, including non-energy consumption (petrochemical materials, lubricating oils).

Because of the considerable importance of emissions of greenhouse gases from combustion processes, there has been an increase in demands for transparency and controllability of

activity data used for inventory calculations, especially in connection with trading in respect to carbon dioxide. Consequently, the energy balance for 2001 and for 1994 (in the *IEA* methodology and following modification according to IPCC requirements) was prepared as part of a set for calculation of emissions of greenhouse gases from combustion processes. This guarantees an unambiguous connection between the balance and emission values.

3.4.2 Direct GHG emissions

Combustion processes in energy management are a source of emissions of a decisive fraction of greenhouse gases. Emissions of carbon dioxide from combustion processes contribute to almost 98% of total emissions of this gas and encompass five *key sources*. Thus considerable attention was paid to inventories of emissions from combustion processes using [1] and [4]. Emissions of direct greenhouse gases, i.e. CO_2, CH_4 and N_2O were calculated on the basis of activity data and emission factors for the fuels burned.

Activity data include the consumption of fuel in combustion processes in energy management. This consumption was determined using the above-described preliminary energy balance. The results of the inventory including activity data are processed in the CRF format, which also includes back-control of the calculation of the "implied" emission factors. Because of the degree of elaboration of the calculation procedures used to date, it was possible to fill out the required CRF tables, with one exception, where the processing industry (1A2) is reported as a whole. The current energy statistics do not provide sufficient data for classification into the individual branches of industry.

Comparison of the results of the inventory for 2001 with the initial year of 1990 indicates a significant decrease in level of emissions of direct greenhouse gases, which basically corresponds to the decrease in domestic consumption of primary fossil fuel sources in this period, as a consequence of a substantial decrease in coal consumption.

Inventory calculations are accompanied by a certain uncertainty. The first uncertainty follows from the use of the preliminary energy balance. The deviation from the total balance may be as large as 5 % in the individual balanced years. In the inventory for 2001, this deviation was eliminated to a considerable degree, as data were finally corrected using the final energy balance, published in March 2003.

Another uncertainty follows from the deriving of emissions from fuel consumption, expressed in energy units. The precision of the determination of the heat capacity plays a decisive role here, especially for coal. Thus the use of specific emission coefficients corresponding to the specific kind of coal, in place of the current *default* factors, could lead to an improvement. However, it follows from [14] that large differences between *default* and country-specific or site-specific cannot be expected.

3.4.3 Precursor emissions

Inventory of ozone precursors (CO, NO_X and NMVOCs) and aerosol precursor (SO_2) in CRF do not require stating of emission factors. Emission precursors estimates for the relevant subcategories (starting with the emission data for 2001) have thus been transferred from NFR to CRF. As was already stated in Chapter 2, the NFR format has recently been implemented for reporting emissions of traditional pollutants under CLRTAP, while the national emission database called REZZO was used as the primary data source. The REZZO – NFR – CRF data transmission enables enhancement of harmonization of all the Czech inventories dealing with some air quality pollutants as GHG precursors.

3.4.4 QA/QC procedures

Activity data required for emissions calculation using the IPCC methodology were determined on the basis of the preliminary energy balance published by CSO in August 2002. The data in this balance were verified on the basis of individual data from the following organizations:

− fuel extraction: Czech Mining Authority, Employers Federation of the Mining and Petroleum Industry, Miners' Association,

− liquid fuel consumption: Czech Association of the Petroleum Industry and Trade (CAPPO),

− production and consumption of natural gas: Annual Report of Distribution Companies of the Gas Industry, Transgas Balance.

Data from transport and household subcategories of were verified and supplemented using specialized models, as described in subchapter 3.1.4.

Final correction of activity data was carried out on the basis of the final energy balance, published by CSO in March 2003. In verifying this balance, it was necessary to make a correction for some imprecision in sources and consumption in the item "other liquid fuels".

The corrected activity data were entered in CRF sheets. Formal control of the correctness and completeness of the data entered in CRF tables was carried out by CHMI. This control was carried out at random.

References

1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

2. *IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1995.

3. Svoboda K.: *Emission factors for nitrous oxide from coal combustion in stationary sources, Report for CHMI,* Prague 1996. (in Czech)

4. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

5. Fott P., Bláha J., Pecka K.: *Inventories of greenhouse gases in 1990-1993*, CHMI, "Global Climate Change" Project , Environmental Project No. 49/14/1/95, Prague 1995. (in Czech)

6. Fott P., Pretel J., Bláha J., Pecka K.: *Inventories of greenhouse gases in the Czech Republic in 1994 and 1995* , CHMI Report, "Global Climate Change" Project , Environmental Project No. 310/1/96, Prague 1996. (in Czech)

7. Fott P.: Refining of emission factors for greenhouse gases under the conditions in the Czech Republic, CHMI Report, "Global Climate Change" Project , Environmental Project No. 310/1/96, Prague 1996. (in Czech)

8. *CORINAIR Default Emission Factor Handbook*, Brussels 1994.

9. Markvart M., Bernauer B.: *Emission factors for nitrous oxide from combustion processes, chemical technology and mobile sources,* Kateko Report for CHMI, Prague 1999. (in Czech)

10. Adamec V., Dufek J., Jedlička J.: *Study of trends in transport in 2000 from the standpoint of the environment,* Transport Research Centre, Brno, May 2000. (in Czech)

11. Jelínek A., Plíva P.: *Emissions from the operation of forest and agricultural vehicles and machinery in 1996,* Research Institute of Agricultural technology, Prague-Řepy, Prague 1997. (in Czech)

12. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1996*, CHMI Report, "Global Climate Change" Project , Environmental Project No. 310/1/97, Prague 1997. (in Czech)

13. Kolat K., Danihelka P. et al: *Study of the formation of N_2O in mobile means and stationary combustion facilities,* Report of the Mining University, Ostrava 1998. (in Czech)

14. Fott, P.: *Carbon emission factors of coal and lignite: Analysis of Czech coal data and comparison with European values*. Environmental Science and Policy (Elsevier), **2**, 1999, p. 347-354.

4. Fugitive Emissions (Category 1B)

Mining, treatment and all handling of fossil fuels are sources of fugitive emissions. They consist mainly of emissions of methane and volatile organic compounds NMVOCs (petroleum extraction and processing). In the Czech Republic, CH_4 emissions from deep mining of hard coal are significant, while emissions from surface mining of brown coal and emissions from landfills and gas distribution are also important. On the other hand, emissions from petroleum extraction and processing are less important. Other industrial activities included in this category are of marginal importance, in respect to both CH_4 and NMVOC emissions. Category 1B also includes CO_2 emissions from removal of SO_2 from combustion products using limestone.

4.1 Source detection

CH_4 emissions are primarily derived from deep mining of hard coal in the Ostrava-Karviná area. A lesser source consists in brown coal mining by surface methods and post-mining treatment of hard and brown coal. Approximately 10% of emissions are formed in the Czech Republic from gas industry in extraction, storage, transport and distribution of natural gas and in its final use. Petroleum extraction and refining processes are less important. NMVOC emissions are formed primarily from petroleum refining and in storage and handling of petroleum products.

National emission factors [1, 2, 7] were used in calculating methane emissions in deep hard coal mining; emission factors according to the IPCC methodology [4] or the earlier version [3] were used for the emission factors for emissions from the surface mining of brown coal and post-extraction treatment. Methane emissions from the gas industry were determined using national emission factors based on the specific emission factors for the individual parts of the gas industry system [5, 6]. Determination of methane emissions from the processes of refining of petroleum is based on the recommended emission factors according to [4].

Of the list sources or categories (8, Chap. 7), Fugitive Emissions from Coal Mining and Handling and Fugitive Emissions from Oil and Gas Operations were evaluated as *key sources* [8] (Tab. 4.1).

Tab. 4.1 Share of CH_4 emissions from individual sub-categories on the overall aggregated emissions

	Character of source	Gas	% of total
Fugitive Emissions from Coal Mining and Handling	Key source	CH_4	3.4
Fugitive Emissions from Oil & Gas operations		CH_4	0.4

4.2 Methane emissions from mining and post-mining coal treatment

Coal mining (in particular hard coal mining) is accompanied by an occurrence of methane. Methane, as a product of the coal-formation process is physically bonded to the coal mass or is present as the free gas in pores and cracks in the coal and in the surrounding rocks. In deep hard coal mining, CH_4 is released from the coal mass and from the surrounding rocks into the mine air and must be removed to the surface to prevent formation of dangerous concentrations in the mine. The mine ventilation must be calculated according to the amounts of gas released. Thus mine gas removal systems were introduced at the end of 1950's in opening new mines and levels in the Ostrava-Karviná coal-mining area, which also permitted long-term monitoring of the amounts of gases and mine air removed. The total amount of methane emitted can be balanced quite accurately from the methane concentrations in the mine air and their total annual volume. The ratio between mining and the volume of methane emissions is given in Tab. 4.2, see [2].

Tab. 4.2 Coal mining and CH$_4$ emissions in the Ostrava – Karvina coal-mining area

	Coal mining	CH$_4$ emissions		Emission factors	
	mil. t/year	mil. m^3/year	kt/year	m^3/t	kg/t
1960	20.90	348.9	250.3	16.7	12.0
1970	23.90	589.5	422.9	24.7	17.7
1975	24.11	523.9	375.8	21.7	15.6
1980	24.69	505.3	362.5	20.5	14.7
1985	22.95	479.9	344.3	20.9	15.0
1990	20.06	381.1	273.4	19.0	13.6
1995	15.60	270.7	194.2	17.4	12.4
1996	15.10	276.0	198.0	18.3	13.1
Total	**167.31**	**3 375.3**	**2 421.3**	**20.2**	**14.5**
1990 till 1996	50.76	927.8	665.6	18.3	13.1

As it is a *key source*, the determined national emission factor has been used to calculate methane emissions since 1996 (calculation at the level of Tier 3), i.e. 18.3 m^3 CH$_4$/t. It should be pointed out that an emission factor of 23.9 m^3 CH$_4$/t, taken from [4], was used up to 1996; this was much higher than the emission factor used in Poland. This emission factor was also used to recalculate the curves for emissions of methane in this category from 1990 to 1995. The activity data are taken from [9].

The use of the emission factor for 1996 - 2000 can be considered satisfactory from the standpoint of [8], as the ratio NG/HC (m^3/t) between natural gas of coal origin (NG - natural gas) and hard coal mining (HC - Hard Coal) did not change significantly in this period Tab. 4.3.

Tab. 4.3 Trends of mined natural gas of coal origin (NG) and its ratio to hard coal (HC) mining

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
NG [mil. m^3]	127.1	124.4	151.3	139.8	139.6	154.0	146.9	128.0	126.5	118.1	96.5	115.6
Ratio NG/HC	6.3	7.2	8.8	8.5	10.2	11.5	11.5	10.1	10.2	10.5	7.0	9.8

During the 1990's, there was a gradual decrease in deep hard coal mining and gas removal is being made more efficient at the present time. Consequently, in the future, it will be necessary to verify the validity of the emission factor being used [13].

Other areas of deep mining in the Czech Republic are not important for methane emissions. In the Kladno mining area, where not quite 1/10 of domestic production was mined to date, methane production is substantially lower, so that safety problems are not created and the energy-production use of mine air would not be profitable. Consequently, the amount of methane emitted in this location is not monitored. As Tier 2 calculation is permissible for *key sources*, the lower limit of the recommended emission factors for mining and post-mining treatment, related to the activity data on mining in the Kladno area, was used for CH_4 emission calculation in this location.

During **surface mining**, methane escaping is not related to specific flow of air and thus it is far more difficult to monitor the amount of methane escaping into the air. Consequently, *default* IPCC emission factors are employed to calculate methane emissions from surface mining and from post-mining treatment and it can be stated that this method is adequate in relation to the lesser importance of emissions from this source, as is confirmed by [8]. However, it would be useful to carry out a study that would determine the ratio between methane produced and brown coal obtained by surface mining, in order to chose an emission factor that would correspond to the national specific characteristics. Research has indicated that no such studies or analyses have so far been carried out.

4.3 Methane emissions from gas extraction, storage, transit, transport and distribution

In the 1990's, the gas industry was one of the most dynamically evolving industrial categories in the Czech Republic. Natural gas is an important trade commodity and consequently its consumption, transport, distribution, storage and supplementary extraction in the territory of the Czech Republic is monitored carefully. As a result, activity data for the methane emission balance are available with high precision in this category.

Methane emissions in this category are basically formed in several ways:

- through poor seals in the flanges and joints, fittings, probes in mining and storage fields and other parts of the pipeline system,
- through pipeline perforation,
- through technical discharge of gas into the air,
- through accidents.

Escapes in the distribution network and household distribution pipes can be considered to constitute the most serious source of emissions. In the 1990's, the distribution network was newly constructed almost entirely from welded plastics and the old pipeline was reconstructed to a major degree in the same manner. Household distribution pipes are subject to strict standards and any poor seals can be identified by the characteristic smell. In addition to safety aspects, all escapes also have an economic impact both for the distribution company and for the end user, so this aspect is carefully monitored and, where possible, immediately remedied. As a whole, the gas distribution is at a high technical level and it can be stated that all escapes are carefully sought out and eliminated.

As a method was developed in the last few years for determining methane emissions in the gas industry using specific emission factors, this sophisticated method of calculation continues to be used, although, from the standpoint of ref. [8], calculation using *default* values would probably suffice.

Qualified estimation of methane emissions is thus carried out using specific emission factors for the individual parts of the gas distribution system [6, 10]. Tab. 4.4 gives the individual

emissions at the individual parts of the gas distribution system determined using the specific emission factors published in January 1998 by the *"Environment, Safety and Health" Working Committee* - WOC 8, and determined by the *International Gas Union* (IGU) [5, 6] and adjusted for specific conditions in the Czech Republic on the basis of consultations with professionals in the gas industry.

Tab. 4.4 CH$_4$ emissions from gas processing, transportation and distribution in 2001

	thous. m^3/year	Determination method
Mining, production and processing	317	EF
High pressure pipelines	800	from the REZZO system
Compressor stations	1 407	EF
Underground storage	3 605	EF
Regulatory stations and measurement	2 200	EF
Distribution networks	5 822	EF
Use of gas (number of users)	8 740	EF
Total	**22 891**	

The total emission value given corresponds to about 0.3% of the total consumption of natural gas in the Czech Republic. The detailed calculation given corresponds to Tier 2.

In conclusion, it should be pointed out that, since 1997, this chapter does not include transport and distribution of town gas, whose production was terminated in 1996, when the entire gas system was converted to natural gas. The factory for production of energy-production gas in the pressure gas plant of Vřesová (Sokolovská uhelná, a.s.) was reconstructed as an integrated steam-gas facility. However, from the standpoint of the overall balance, the importance of this source of fugitive emissions lies below the borderline of the precision of the other professional estimates.

4.4 Methane emissions from petroleum extraction, refining and storage

As the fraction of this category makes a minority contribution to overall methane emissions in the category Fugitive emissions from operations connected with petroleum and gas, this chapter is limited to a brief commentary.

Calculation of methane emissions in domestic petroleum production was carried out using the emission factor determined in [1] on the basis of data from ref. [11], and currently has a value of 5.287 kg/PJ of extracted petroleum. This emission factor is somewhat higher than the maximum value recommended by IPCC (4.670 kg/PJ); however, it is the same order of magnitude. The calculation corresponds to Tier 2.

In the recent past, Czech refineries have undergone a quite extensive process of innovation and reconstruction, to decrease technical losses of raw materials and final products. Comprehensive verification has been carried out of the seals of the individual fittings, pumps and all the technical equipment. This entire process, which was carried out mainly for economic reasons, also led to a decrease in overall emissions, especially of NMVOCs. Consequently, the emission factors taken from [4] can be considered to correspond to the current technical condition of refineries in this country. In this connection, it should be pointed out that fugitive emissions from refinery technology couldn't be determined by direct measurements, as they are not connected with specific air outlets or chimneys. Thus, they can be determined only on the basis of professional estimates from balance losses or using emission factors. The resultant emissions of the individual substances were compared with the data in the national emission database and are of the same order of magnitude.

As, according to the literature, methane constitutes about 10% of total VOC emissions, it can be stated that the emission factor for methane would correspond to a level of about 0.07 kg/t of processed petroleum, which is the upper limit given in [4]. Technical progress in the past has permitted reduction of emissions by about 30%. Consequently, an emission factor value of 1.150 kg/PJ is used to calculate methane emissions from petroleum refining. The emission factor for storage of petroleum was found by a similar method as being at the level of 250 kg/PJ. Petroleum products practically do not contain methane and thus emissions from storage and handling of petroleum products are not calculated.

Because of the uncertainty, it is necessary to evaluate methane emissions in this subcategory at the level of Tier 1. However, the uncertainty entailed cannot significantly affect the overall balance.

4.5 *Total fugitive emissions – summary and QA/QC procedures*

4.5.1 Activity data and emission factors

Activity data on the extraction of the individual energy carriers (coal, petroleum, gas) and on batches of petroleum in the petrochemical industry are available in the Mining Yearbook [9], in the Statistical Yearbook of the Czech Republic and, since 1998, in the periodical publication Energy Management in the Czech Republic in Numbers [12]. Data on the gas distribution system are monitored and collected by TRANSGAS a.s. and the Czech Gas Federation. All the activity data employed can be considered to have a relatively high level of precision (± 5%).

Methane emissions were calculated using national emission factors determined in previous years from various sources given in the literature survey, with the assistance of professionals for the individual categories of sources. In relation to expected future developments, it will, however, be necessary to regularly refine the emission factors values employed. All the required information on activity data could be entered in tables in CRF format because of the high validation and in relation to the complexity of the procedures used to calculate the emissions to date.

Tables 4.5 and 4.6 illustrate the calculation of fugitive emissions of methane from solid, liquid and gaseous fuels.

Tab. 4.5 Calculation of CH$_4$ emissions from coal mining in 2001

	A	B	C	D	E
	Ammount of Coal Produced	*Emission Factor*	*Methane Emissions*	*Conversion Factors*	*Methane Emissions*
	[mil. t]	[m^3 CH$_4$/t]	[mil. m^3]	[Gg CH$_4$/10^{6}m^3]	[Gg CH$_4$]
			C=A*B		E=C*D
Mining (I - III)	15.138	17.8	270	0.67	180.6
OKR (Tier 3)*	*14.246*	*18.3*	*261*	*0.67*	*174.7*
Ost. (Kladno -Tier 1)	*0.892*	*10.0*	*9*	*0.67*	*6.0*
Post-Mining (Tier 1)	15.138	2.4	36	0.67	23.9
OKR (Tier 1)*	*14.246*	*2.45*	*35*	*0.67*	*23.4*
Ost. (Kladno - Tier 1)	*0.892*	*0.9*	*1*	*0.67*	*0.5*
Mining (Tier 1)	47.960	1.15	55	0.67	37.0
Post-Mining (Tier 1)	47.960	0.1	5	0.67	3.2
				Total	**244.74**

* Ostrava-Karviná coal-mining area

Tab. 4.6 Calculation of CH$_4$ emissions from oil and natural gas in 2001

	Tier	A	B	C	D
		Activity	Emission Factors	CH$_4$ Emissions	Emissions CH$_4$
				[kg CH$_4$]	[Gg CH$_4$]
				C = (A x B)	D = (C/10^6)
Production	**OIL**	*PJ oil produced*	*kg CH$_4$/PJ*		
(domestic production)	3	7.35	5 287	38 883	0.039
Refining		*PJ oil refined*	*kg CH$_4$/PJ*		
	1 - 2	254.3	1 150	292 408	0.292
Storage		*PJ oil refined*	*kg CH$_4$/PJ*		
	1	254.3	250	63 567	0.064
				CH$_4$ from oil	**0.395**
Production/Processing	**GAS**	*PJ gas produced*	*kg CH$_4$/PJ*		
(domestic production NG)	2	6.38	49 748	317 347	0.317
Transmission & Distribution		*PJ gas consumed*	*kg CH$_4$/PJ*		
(transit transport, high and low pressure pipeline)	2	1 382.2	13 724	18 969 081	18.969
Other Leakage		*PJ gas consumed*	*kg CH$_4$/PJ*		
Underground storage	3	72.46	49 748	3 604 621	3.605
				CH$_4$ from gas	**22.891**

4.5.2 Emission trends

Determination of the consistency of time trends is one of the requirements of the *Good Practice Guidance*. For methane emissions from the main key category - Mining and post-mining treatment of coal - the time series after recalculating data after 1996 is consistent and corresponds to the trends in coal mining in this country. The original data in the following table (Tier 1) were replaced by data at the Tier 3 level.

Tab. 4.7 Trend of CH$_4$ emissions from coal mining and post-mining activities [Gg]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Original value	*427.0*	*381.0*	*363.0*	*353.0*	*338.0*	*367.0*						
Present value	361.9	321.0	306.0	298.0	282.0	276.6	268.5	263.5	253.1	229.0	239.0	244.7

The time series for the category of methane emissions from petroleum processing and from the gas industry are also sufficiently consistent and their decreasing trend in the second half of the 90's is a result of modernization of technology in these branches.

Tab. 4.8 Trend of CH$_4$ emissions from oil and natural gas activities [Gg]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Oil and natural gas	32.20	35.40	35.90	35.30	34.60	38.00	32.00	35.00	28.20	28.80	28.77	22.89

For conversion into CRF format, data for 1994 were newly recalculated on the basis of the refined emission data and specific process emissions. In a number of cases, the results submitted in this report can exhibit certain deviations from the original data presented in previous years; this is also true of data given in the Second National Communication.

4.5.3 Precursor emissions

Ozone precursors (NO$_X$, CO, NMVOCs) and aerosols (SO$_2$) from this category are generated primarily in the processes of treatment of petroleum and in its storage, and also in other handling of petroleum and petroleum products. Emission data for precursors (since 2001) have been inserted into CRF format by conversion from corresponding subcategories of the NFR format, similarly as in the other categories.

4.5.4 QA/QC procedures

The application of control mechanisms in inventory of fugitive CH$_4$ emissions is an important element of data correctness verification and uncertainty evaluation. The very nature of fugitive emissions leads to needs for internal and external controls, as these emissions are not related to specific outlets and consequently cannot be measured directly. Thus, it is necessary to employ other data than those provided, e.g., by analysis of combustion products from furnaces or waste air from technical facilities.

Accordingly, determination of emission factors is a very complex matter. On the basis of the collected data, emission factors were determined for the individual segments of category 1B and compared with the default values (*Tier 1*); these values were then used to calculate fugitive emissions. The newly determined emission factors for deep mining were also used to correct CH$_4$ emissions for GHG inventories 1990 to 1995.

Internal quality control

For the purposes of internal quality control, the calculations were based on basic requirements that are defined as follows:

- routine control of consistency to ensure data integrity and their correctness and completeness;

- identification and correction of errors and omissions;

- documentation and archiving of all material used for the inventory preparation and QC activities.

Control of quality of the processed by national expert team is carried out both on the basis of the emission factors and activity data used. The consistency of activity data is controlled on the basis of the following sources:

- fuel extraction: Czech Mining Authority, Employers Federation of the Mining and Petroleum Industry, Miners' Association:

- extraction of domestic petroleum: Employers Federation of the Mining and Petroleum Industry, Miners' Association, Moravian Petroleum Mines;

- production and consumption of natural gas: Annual Report of Distribution Companies of the Gas Industry, Transgas Balance.

These sources have been also used in other parts of GHG emission inventory, e.g. in Chapter 3 - *Emissions from Combustion Processes*, resulting in cross-control within the working team. The emissions calculated from the emission factors are then compared with previous years and a check is made to ensure that no sudden changes have occurred. All data (source and calculated) are stored by the national expert team.

External control

In 2002, implementation of external control of emission factors and of the volume of fugitive methane emissions led to the need to create an independent discussion forum of specialists, where these values could be subjected to analysis. At the instigation of national inventory experts, the conference "Natural Gas Emissions", which was prepared jointly with the Czech Gas Union, was held in October 2002. Technologists and environmental specialists from the individual enterprises presented here their new results. Inventory expert team presented method of methane emissions calculation to conference and asked for comments a correctness of methodology used. The discussion led to general examination of methodological procedures. Group of external experts assured the inventory expert team that input data and the calculation procedures are correct.

References

1. Fott P., Pretel J, Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1996, "Global Climate Change III" Project*, Environmental Project No. 310/1/97, Prague 1997. (in Czech)

2. Takla G., Nováček P.: *Emissions of mine gases in the Ostrava-Karviná coal-mining area and potential for minimization,* Proceedings from the conference Emissions of natural gas - economic and environmental impacts, ČPNS Prague May 1997. (in Czech)

3. *IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1995.

4. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC, 1997.

5. *Gas and the Environment*, 20th World Gas Conference, Copenhagen 1997.

6. Alfeld, K.: *Methane Emissions Produced by the Gas Industry Worldwide*, IGU Study Group 8.1: Methane emissions, Essen, January 1998.

7. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1998*, CHMI Report, Prague 1999. (in Czech)

8. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

9. *MiningYearbook*, 1994 – 1999. (in Czech)

10. *Gas and the Environment*, 21th World Gas Conference, Nice 2000.

11. UNIPETROL and the environment - *Report on the environmental impacts of the Unipetrol Group in 1998,* UNIPETROL 1999. (in Czech)

12. Energy management in the Czech Republic in numbers in 1994 – 1997, 1994 – 1998, 1995 – 1999 and 1996 – 2000; KONEKO Marketing Ltd. Prague, December 1998, November 1999, November 2000, November 2001. (in Czech)

13. Takla, G.: Methane emissions from deep coal mining, national conference "Natural Gas Emissions – New Clean Air Act and international reliability of the methane emission inventory in the Czech Republic", Czech Gas Federation, 2002. (in Czech)

5. Emissions from Industrial Processes (Category 2)

5.1 Source detection

This category includes only emissions from actual processes and not from fuel combustion used to supply energy for carrying out these processes. For example, in the production of cement, consideration is given only to emissions derived from the thermal decomposition of mineral raw materials (specifically CO_2 emissions from the decomposition of limestone) and not from fuel used to heat the rotary kiln (considered in category 1A2). It should also be borne in mind that emissions occurring during petroleum refining belong in category 1B (fugitive emissions).

In respect to emissions of direct greenhouse gases, these consist only in emissions of CO_2 in the production of mineral products (cement, glass). This source can be considered a *key source* according to the *Good Practice Guidance* [2], although it is far less significant compared to combustion of fossil fuels. The production of nitric acid, which leads to emissions of N_2O, can be considered to be a source lying on the borderline between key and non-*key sources*. Tab. 5.1 gives a summary of sources of direct greenhouse gases in category 2.

Tab. 5.1 Overview of the most important sources from this category

	Character of source	Gas	% of total
Minerals production (decarbonization)	Key source	CO_2	1.5
HNO_3 production	Key source	N_2O	0.8

Other sources of direct greenhouse gases are minor, except of CO_2 emissions from iron and steel production, which have so far been reported in the energy category 1A2. In the 2001 inventory, these emissions were already re-classified as emissions from Industrial processes, 2C1. Naturally, this constitutes a quite important key source under Industrial processes. In this way, the relevant rearrangements will be applied on the whole data series.

Emissions from ammonia production (including hydrogen production by steam gasification followed by the shift reaction) should also be reported in the Industrial processes category. However, they are two reasons to include these emissions currently under Energy (1A2) - to respect existing continuity, and due to some difficulties in identification of the amount of gasified fuel (black oil). These emissions are also included for illustration in the sector tables for category 2; however, to avoid double counting they are not included in the sum of this category.

According to the IPCC categorization of sources, this category also includes emissions from production and use of HFCs, PFCs and SF_6. It is no production of these gases in the Czech Republic. Emissions related to their usage are analyzed in a separate Chapter 10.

5.2 Carbon dioxide emissions

Cement production is one of the traditional anthropogenic sources of carbon dioxide included in inventories; however, its importance is incomparably smaller than the combustion of fossil fuels. In principle, carbon dioxide emissions can be calculated according to the IPCC methodology from the production of clinker or cement. The latter approach was employed in this inventory, because statistical information on cement production is available in the Czech Republic. The same emission factor taken from the *IPCC Guidelines* [1], i.e. 0.4985 t CO_2/t cement, was used for emissions from cement throughout the nineteen nineties. In 2001, CO_2 emissions decreased slightly compared to previous years and equalled 1 790 Gg CO_2.

Glass production is a somewhat less important source, where CO_2 emissions (210 Gg) are derived particularly from the decomposition of alkaline carbonates added to glass-making sand. The emission factor value of 0.14 t CO_2/t glass was taken from the new version of the *Atmospheric Emission Inventory Guidebook* [3].

Another "apparent" source of CO_2 emissions is the production of lime by calcination of limestone. However, these emissions are immediately compensated by chemical bonding in hardening of mortar (sink). In contrast, cement hardens by a different mechanism.

From the chemical perspective, sulfur removal from combustion products in coal combustion, using limestone, is a related source of CO_2 emissions, although it is not of great importance. Here, it holds that one mole of SO_2 removed releases one mole of CO_2 without regard to the sulfur-removal technology employed and the stoichiometric excess. However, this source is reported in category 1B. These amounts have, understandably, increased somewhat in the last three years, to a value of about 0.5 Mt CO_2 as a consequence of the extensive introduction of sulfur removal, especially in power plants. However, this figure is not expected to increase further.

In accordance to the *Good Practice Guidance*, starting with GHG emission inventory 2001, recategorization of the CO_2 emissions formed in the metallurgy industry in the process of production of iron and steel was carried out. These emissions, which are connected with the actual metallurgical process, were previously included in category 1A2. For 2001, these emissions, equaling 2524 kt CO_2, were transposed to category 2C1. Obviously, they constitute a key new source in category 2.

CO_2 emissions were determined for subcategory 2C1 using a procedure corresponding to Tier 1 of the *Good Practice Guidance* for 2C1. This calculation was based on the amount of coke burned in blast furnaces, as stated by the Energy Balance for the Czech Republic for 2001 [6], equal to 23 811 TJ (829 kt). The calculation was carried out using the carbon emission factor for coke, 29.5 t C/TJ, which is the *default* value according to [1]. As the final products in metallurgical processes are mostly steel and iron with very low carbon contents, the relevant correction for the amount of carbon remaining in the steel or iron was taken into account by using factor 0.98, i.e. the same factor that is standardly used for combustion of solid fuels (the oxidation factor). The major part of CO_2 emissions calculated in this manner, is emitted in combustion of blast-furnace gas, while a smaller part is derived from heat treatment (improvement) of pig iron (total CO_2 emissions corresponding to level 2C1 equal 2 524 kt).

Other CO_2 emissions generated in metallurgical plants in the production of iron and steel, including emissions from agglomerates (sinter), continue to be included in subcategory 1A2 (combustion in the manufacturing industry). Another statistical data related to coke for 2001 are given in [6] as follows: production of metallurgical coke - 2 646 kt (75 944 TJ), total

amount of coke produced (including metallurgical) - 3 522 kt (98 039 TJ), and total coke resources (also including imports, exports and change in stocks) - 3 177 kt (88 668 TJ).

5.3 Methane and nitrous oxide emissions

Nitrous oxide emissions in this category are derived mainly from the production of nitric acid. Nitrous oxide is generated as a by-product in the catalytic process of oxidation of ammonia. It follows from the newest studies [4] that the amount depends on the technology employed: higher emission factor values are usually given for the process carried out at normal pressure, while lower values are usually given for the medium-pressure process. Two types of processes are carried out in this country, at pressures of 0.1 MPa and 0.4 MPa. The amount of nitrous oxide in the exit gases is also affected by the type of process employed to remove nitrogen oxides, NO_X (i.e. NO and NO_2). In this country, the process of Selective Catalytic Reduction (SCR) is mostly used, which slightly increases the amount of N_2O, and also to a certain degree NonSelective Catalytic Reduction (NSCR), which also removes N_2O to a considerable degree. The final value of aggregated emissions for 2001 equalled 6.57 kg N_2O/t HNO_3 (taken as 100% HNO_3) [4].

Study [4] recommends the following emission factors for various types of production technology and removal processes:

Tab. 5.2 Emission factors for N_2O recommended by [4]

Pressure in HNO_3 production	0,1 MPa			0,4 MPa		
Technology RENOX	--	SCR	NSCR	--	SCR	NSCR
Emission factors N_2O [kg N_2O/ t HNO_3]	9.05	9.20	1.80	5.43	5.58	1.09

The emission factors corresponding to the technologies in operation in this country are given in bold. The emission factors for the basic process (without RENOX technology) are in accord with the principles given in [1] or [2]. The effect of the NO_X removal technology on the emission factor for N_2O was evaluated on the basis of the balance calculations of the authors of study [4].

Study [15] also gives the value of N_2O emissions from the production of caprolactam starting this year: 0.3 kt N_2O per annum. However, this amount is small compared with other sources. Adipic acid, which is considered to be a significant source of N_2O on a global scale, has not been manufactured in the Czech Republic for some time. Further potential sources of N_2O from other nitration processes in chemical technology should be negligible according to study [4].

Industrial processes emit only 3.40 Gg of methane (in 2001), of which approximately one half corresponds to escape of carbonization gas in coke production.

5.4 Total industrial emissions - summary and QA/QC procedures

5.4.1 Activity data and emission factors

Collection of activity data in this category is limited, more than elsewhere, by the present legislation, which complicates the releasing of statistical data on manufactured products where the number of producers is smaller than (or equal to) three. In this connection, it should be pointed out that, in most cases, there is no reason to refuse to reveal production figures (enterprises have no reason to keep production secret).

Thus, three approaches were used to obtain the necessary data

a) CSO data, where available (i.e. there were more than 3 manufacturers),

b) questionnaires posed to the individual producers,

c) information from the REZZO operational records.

For example, information on the amount of cement produced is available in the Statistical Yearbook [5] (there are more than 3 producers), while information on the amount of nitric acid produced is lacking (three producers), so that the overall amount was determined by questioning all three producers [4].

The emission factors were discussed above: for the production of cement, the *default* emission factor from the IPCC methodology was employed because of the consistency of the time series; for the production of nitric acid, the national and technologically specific values were used (derived according to [1, 2]).

5.4.2 Emission trends

Tab. 5.3 Emission trends from cement and HNO$_3$ production

	Emissions of CO$_2$ [Gg] from cement production	Emissions of N$_2$O [Gg CO$_2$ eq.] from HNO$_3$ production	
		inventory	according to [4]
1990	3 207	1 127	1 123
1991	2 801	868	
1992	3 063	1 085	921
1993	2 693	837	705
1994	2 644	942	
1995	2 642	1 042	
1996	2 479	1 032	1 004
1997	2 498	1 117	1 036
1998	2 430	1 113	1 113
1999	2 114	915	915
2000	2 040	1 041	
2001	1 790	1 029	

One of the requirements imposed is that consistency of the trends in time be ensured [2]. CO$_2$ emissions from cement production, which contribute most to the overall emissions in this category, constitute a relatively continuous time series, which has exhibited only a slight decrease since 1990. In contrast, emissions from the production of nitric acid did not decrease and tended to fluctuate around a value of 1 Mt of CO$_2$ equivalent.

Tab. 5.3 gives the emissions of N$_2$O from production of nitric acid, i.e. both the values taken from the existing inventories and also refined values taken from study [4]. It seems that the differences are not great enough to warrant recalculating the original values.

5.4.3 Precursor emissions and QA/QC procedures

Emission estimates of precursors for the relevant subcategories (starting with inventory 2001) have been transferred from NFR to CRF, as described in Chapter 3.3.

The activity data available in the official CSO materials related to QA/QC were independently determined by experts from CHMI and KONEKO Marketing Ltd. and were mutually compared. The continuity from previous years was determined for activity data that is not available in the official CSO statistics and that was explored by experts (e.g. the amount of nitric acid produced, including the separate values for the individual technologies). Experts of CHMI, and vice versa additionally controlled most of the calculations carried out by experts of KONEKO Marketing Ltd.

Data corresponding to amount of coke fed into blast furnaces (829 kt) seems to be too low according to leading authors responsible for preparation of the GHG emission inventory, compared to the other CSO data related to coke (see the data in section 5.2). Therefore, these data were verified again. It was found that this value is in fact given in the 2001 Energy Balance [6]. However, even if the value of 829 kt in the CSO statistics were underestimated, this would not affect the total national CO_2 inventory, but the relevant emissions would only be included elsewhere (in 1A2).

References

1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC 1997.

2. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

3. EMEP/CORINAIR *Atmospheric Emission Inventory Guidebook*, UN ECE/EMEP 2000.

4. Markvart M., Bernauer B.: *Emission trends in nitrous oxide from industrial processes in thenineteen nineties,* Report for CHMI, Prague 2000. (in Czech)

5. *Statistical Yearbook 2001*, CSO, Prague 2001.

6. *Energy Balance of the Czech Republic,* CSO, Prague 2003.

6. Emissions from Solvent Use (Category 3)

This category includes particularly emissions of NMVOC (ozone precursor) from the use of solvents, which are simultaneously considered to be a source of CO_2 emissions (these solvents are mostly obtained from fossil fuels), as their gradual oxidation in the atmosphere is also a factor. However, the use of solvents is not an important source of CO_2 emissions - in 2000, CO_2 emissions were calculated at the level of 0.34 Mt CO_2.

This category (Solvent and Other Product Use) also includes N_2O emissions from solvent use in the food industry and in health care. These not very significant emissions corresponding to 0.69 kt N_2O were derived from production in the Czech Republic.

The *IPCC Guidelines* [1] uses the CORINAIR methodology [2] for processing NMVOC emissions in this category. The manual for CORINAIR [3], which gives the following conversions for the relevant activities, can be used in conversion of data from the CORINAIR (i.e. SNAP) structure to the IPCC classification.

Tab. 6.1 Conversion from SNAP into IPCC structure

SNAP	SOLVENT AND OTHER PRODUCT USE	IPCC	
06 01	Paint application Items 06.01.01 to 06.01.09	3A	Paint application
06 02	Degreasing, dry cleaning and electronic Items 06.02.01 to 06.02.04	3B	Degreasing and dry cleaning
06 03	Chemical products manufacturing or processing. Items 06.03.01 to 06.03.14	3C	Chemical products
06 04	Other use of solvents + related activities Items 06.04.01 to 06.04.12	3D	Other
06 05	Use of N_2O Items 06.06.01 to 06.06.02	3D	Other

Inventories of NMVOC emissions for 2001 for the category 3 were prepared on the basis of a study prepared by SVÚOM s.r.o. Prague [4] and its updating for 2001.

These studies emphasize that it is very difficult to process the information obtained from the individual sources because of the lack of completeness and lack of comprehensive nature of the data which is collected and stored for different reasons than evaluation of the environmental impact of the individual products. Basically, inventories of NMVOC emissions are prepared in the balance manner, which attempts to include all solvents and materials containing VOCs that are used in the Czech Republic in the given year. This balance approach corresponds to the methodology in the energy category: (production + imports - exports) of VOCs corresponds to the annual emissions. The main documents employed are
- statistical information on producers and imports from the *Czech Statistical Office*,
- REZZO data,
- annual reports of the *Association of Coatings Producers* and *Association of Industrial Distilleries*,
- information from the *Customs Administration*.

Tab. 6.2 Emissions data sources (NMVOC)

A Paint Application	REZZO, AVNH, CSO, CSpr
PAINT APPLICATION - MANUFACTURE OF AUTOMOBILES	REZZO, SZdr
PAINT APPLICATION - CAR REPAIRING	OOd
PAINT APPLICATION - CONSTRUCTION AND BUILDINGS	OOd
PAINT APPLICATION - DOMESTIC USE	OOd
PAINT APPLICATION - COIL COATING	REZZO, SZdr, OOd
PAINT APPLICATION - WOOD	REZZO, SZdr, OOd
OTHER INDUSTRIAL PAINT APPLICATION	OOd
OTHER NON INDUSTRIAL PAINT APPLICATION	OOd
B Degreasing and Dry Cleaning	REZZO, CSO, CSpr
METAL DEGREASING	REZZO, OOd
DRY CLEANING	OOd
ELECTRONIC COMPONENTS MANUFACTURING	OOd
OTHER INDUSTRIAL CLEANING	
C Chemical Products Manufacture / Processing	REZZO, AVNH, CSO, CSpr
POLYESTER PROCESSING	REZZO
POLYVINYLCHLORIDE PROCESSING	REZZO
POLYSTYRENE FOAM PROCESSING	REZZO
RUBBER PROCESSING	REZZO, SZdr
PHARMACEUTICAL PRODUCTS MANUFACTURING	OOd
PAINTS MANUFACTURING	REZZO, AVNH, OOd
INKS MANUFACTURING	REZZO, AVNH, OOd
GLUES MANUFACTURING	REZZO, AVNH, OOd
ADHESIVE MANUFACTURING	OOd
ASPHALT BLOWING	OOd
TEXTILE FINISHING	OOd
LEATHER TANNING	REZZO, OOd
D Other	REZZO, APL, CSO, CSpr

Abbreviations used:

REZZO – *Register of Emissions and Sources of Air Pollution*
CSO - *Czech Statistical Office*
CSpr – data from *Custom Office of the Czech Republic*
AVNH – data from annual report of *Association of Coatings Producers*
APL – data from annual report of *Association of Industrial Distilleries*
SZdr – data from direct investigation in the most important sources
OOd – data from expert appraisal

Source category "D other" contains sub-categories tabulated below, including used methodology of NMVOC emissions estimation

Tab. 6.3 Emissions data sources (NMVOC) – sub-category D

Glass wool enduction	REZZO, OOd
Mineral wool enduction	REZZO, OOd
Printing industry	REZZO, AVNH, CSU, CSpr, OOd
Fat, edible and non edible oil extraction	REZZO, OOd
Application of glues and adhesives	OOd
Preservation of wood	OOd
Undearseal treatment and conversation of vehicles	OOd
Domestic solvent use (other than paint applications)	OOd
Vehicles dewaxing	OOd
Pharmaceutical products manufacturing	OOd
Domestic use of pharmaceutical products	OOd

The current method of preparing inventories of NMVOC emissions will soon become obsolete in the category 3 and will be substantially innovated as a consequence of implementation of EC Directive 99/13/EC in the Czech legislation. (Decree of MoE No. 355/2002 Coll., which sets emission limits and other conditions for the operation of other stationary sources that emit volatile organic compounds from organic solvent use and from distribution and storage of petrol, came into force on July 11, 2002. Therefore, beginning of 2002, it will be possible to incorporate into GHG inventory NMVOC activity and emission data from the REZZO national emission database [5].

References

1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

2. *EMEP / CORINAIR Atmospheric Emission Inventory Guidebook*, UN ECE - EMEP 1996.

3. *CORINAIR Software*, Instruction for Use, EEA / ETC / AE, Copenhagen 1996.

4. Commentary on the emission inventory for 1999 on the decrease in NMVOC emissions in the sector "Solvent use and applications - 060000", SVÚOM, s.r.o., Prague, November 2000. (in Czech)

5. Clean Air Act (86/2002 Coll.) and related legislation. (in Czech)

7. Emissions from Agricultural Production (Category 4)

7.1 Source detection

GHG emissions from agriculture category under national conditions consist mainly of emissions of methane and nitrous oxide.

Methane emissions are derived from animal breeding. These are derived primarily from enteric fermentation (digestive processes), which is manifested most for ungulate animals (in this country, mostly cattle). Other emissions are derived from fertilizer management, where methane is formed under anaerobic conditions (with simultaneous formation of ammonia which, however, is not monitored in the framework of greenhouse gas inventories).

Nitrous oxide emissions are formed mainly in denitrification processes in soils, mainly under anaerobic conditions. The anthropogenic contribution that is determined in the national inventory of greenhouse gases is caused by nitrogenous substances derived from inorganic nitrogen-containing fertilizers, manure from animal breeding and nitrogen contained in parts of agricultural crops that are returned to the soil (for example, in the form of straw together with manure, or that are ploughed into the soil). In addition, according to the *IPCC Guidelines* [1], emissions are included from stables and fertilizer management and indirect emissions derived from atmospheric deposition and from nitrogenous substances flushed into water courses and reservoirs. Simultaneously, there was a significant increase in the emission factor for determining emissions from agricultural soils. (The method for methane emissions has not undergone any substantial changes).

For these sources (categories of sources), three to five sources or categories were evaluated according to the *Good Practice Guidance* [10] as *key sources*. According to this approach, sources or categories of sources are related to the given pollutant. Sources or their categories defined according to [13] and related to the category 4, including their contribution to aggregated emissions, are given in Tab. 7.1.

Tab. 7.1 Overview of the most important sources from category 4

	Character of source	Gas	% of total
Direct emissions of N_2O from agriculture soils	Key source	N_2O	1.9
Indirect emissions of N_2O from agriculture activities	Key source	N_2O	1.3
Enteric fermentation	Key source	CH_4	1.2
Manure management	-	CH_4	0.5
Manure management	-	N_2O	0.3

7.2 Methane emissions

As mentioned above, methane emissions from the breeding of farm animals are caused both by enteric fermentation and also by the decomposition of animal excrement (manure). Determination of these emissions was prepared at the level of both Tier 1 and Tier 2. If enteric fermentation is considered according to Tab. 7.1 to constitute a *key source*, preference should be given to determination in Tier 2. This calculation arose in 1994 in connection with the now historical study [7] and was reviewed by CHMI in 1996, where only minimal adjustments were made to the emission factors [4]. In principle, emissions from animal excrement could be calculated according to Tier 1 (this is not a *key source*); however, in the light of tradition and consistency of the time series, the final values were also calculated according to Tier 2 using the emission factors from studies [3, 4]. The number of animals required for the calculation was taken from the Statistical Yearbook [5].

7.2.1 Tier 1

In deciding on the relevant emission factors in the area of animal production, the *IPCC Guidelines* [1, 2] permits a choice between developed and undeveloped countries or between the countries of Western and Eastern Europe. Because of the tradition of intensive agriculture in the Czech Republic and the cultural similarity to Western Europe, values for developed countries or Western Europe were used. For comparison, calculation was also carried out for an Eastern European country. For emissions from animal manure, a further parameter is the temperature zone (cool, temperate, warm). As the average annual temperature in the Czech Republic does not exceed 10 ^{o}C, the values for a cooler climate (< 15 ^{o}C) were selected. Determination in Tier 1 was carried out mainly for the purposes of control, while the final sums were drawn up on the basis of emissions determined according to Tier 2.

7.2.2 Tier 2

The emission factor for methane from fermentation (EF) in kg p.a. according to [1] is proportional to the daily food intake and the conversion factor. It thus holds that

$$EF = 365/ 55.65 * \text{daily food intake} * Y,$$

where the daily food intake (MJ/day) is taken as the mean feed ration for the given type of farm animal (there are several subcategories for cattle) and Y is the conversion, which also differs according to the kind of farm animal (usually 0.06 to 0.08 for cattle). The conversion factor of 55.65 has dimensions of MJ/kg CH_4. The feed ration values and conversion in earlier inventories [7-9] were taken from the domestic data at that time [6] and are given in Tab. 7.2. The accepted conversion value of 0.08 for cattle is somewhat higher than the usual value given for Western Europe of 0.06 [1]. For cattle other than dairy cattle, the number of head in the individual subcategories (e.g. calves) is also given for 1990, so that it is possible to calculate the aggregated emission factor for the entire category of other (non-dairy) cattle.

Tab. 7.2 Input data for original calculation of CH$_4$ emissions from livestock according to Tier 2 [6]

Livestock (data from 1994)	Stock [thous. pcs]	Dose [MJ/day]	Y -	VS [kg/day]	Bo [m^3/kg]	MCF -
Dairy cows	1 195	128	0.08	5.6	0.24	0.01
Other cattle	2 165			3.6	0.17	0.01
Cows	350	104	0.08			
Breeding bulls	1	95	0.08			
Pre-weaning calves	60	10	0.08			
Increscent bulls and heifers	626	21	0.08			
Young bulls and heifers	1 128	45	0.08			
Pigs	4 589	26	0.02	0.8	0.45	0.10
Poultry	33 278	1	0.01	0.03	0.32	0.01
Horses	25	90	0.08	4.5	0.33	0.01
Sheep	430	15	0.08	0.7	0.19	0.01
Goats	42	10	0.07	0.5	0.17	0.01

The emission factors for methane from animal manure are calculated for each kind of farm animals according to the equation [1, 2]

$$EF = VS * 365 * Bo * 0.67 * MCF,$$

where EF is the emission factor [kg p.a.], VS is the daily excretion (production of decomposing organic substances in the manure) [kg/day], Bo is the maximum methane production in the excretion [m^3/kg$_{VS}$] and MCF is the conversion factor for the given system of manure storage (deposition). The values of VS, Bo and MCF employed are given in Tab. 7.2. In accord with the studies [5-7], the values of VS were taken from domestic sources [6], which differ somewhat from the recommended values in [1]. The Bo and MCF values were taken from [1], factor MCF = 0.01 corresponds to open deposition of manure (in the cold temperature zone), the value 0.1 (for) pigs corresponds to the usual manner of storing liquid pig manure. The emission factors to determine methane emissions from the breeding of livestock according to Tier 2 were recently verified and up-dated on basis of a new study by domestic agricultural specialists [4]. The emission factors were calculated using zootechnical data from 1995. The original and updated data are given in Tab. 7.3.

Tab. 7.3 Actualized emission factors of CH$_4$ from livestock (Tier 2)

	Emission factors[kg CH$_4$/pcs.year]			
	Original value [6]		Present value [4]	
	Fermentation	Manure	Fermentation	Manure
1 Cattle				
a) Dairy cows	67.16	3.29	68.20	3.29
b) Other cattle	24.48	1.50	23.61	1.01
3 Sheep	7.87	0.33	5.01	0.23
4 Goats	4.59	0.21	4.13	0.19
6 Horses	47.22	3.63	47.20	3.63
8 Pigs	3.41	8.80	3.41	7.87
9 Poultry	0.07	0.02	0.07	0.02

It is apparent from Tab. 7.3 that there are only minimal differences between the former and newly up-dated emission factors. Tab. 7.4 gives a comparison of the emissions of methane

from agriculture calculated for Tier 1 and 2 and for Western Europe (WE) and Eastern Europe (EE).

Tab. 7.4 Comparison of CH$_4$ emissions results in 1997 calculated by various method [Gg]

	Dairy cow	Other cattle	Pigs	Other animals	Total
Tier 1 (WE)	80	63	18	4	165
Fermentation	*70*	*56*	*6*	*2*	*134*
Manure	*10*	*7*	*12*	*2*	*31*
Tier 1 (EE)	61	70	22	4	157
Fermentation	*57*	*65*	*6*	*2*	*130*
Manure	*4*	*5*	*16*	*2*	*27*
Tier 2 (J)	50	29	46	4	129
Fermentation	*48*	*27*	*14*	*4*	*93*
Manure	*2*	*1*	*32*	*1*	*36*

It is apparent from Tab. 7.4 that the results of the calculation do not greatly differ for Western and Eastern Europe. For enteric fermentation, the results calculated according to Tier 2 [4, 6] are about one third lower than the corresponding values calculated for Tier 1, for both Eastern and Western Europe. In contrast, for emissions from manure, the resultant values are similar for Tier 1 and 2; however, according to Tier 2, they are caused especially by emissions from pig manure. A cattle breeding does not make a significant contribution to emissions from enteric fermentation. The final sums for methane emissions were drawn up using data calculated at Tier 2, taking into account national zootechnical data. Nonetheless, the difference in emissions of methane from enteric fermentation calculated for Tier 1 and 2 somewhat exceed the usual expected error of ≤ 30% in determining methane emissions from enteric fermentation [10].

However, it is also necessary to take into account that both these studies were prepared prior to publishing of *Good Practice Guidance* and that the first study was prepared even prior to publishing of the first version of methodology [2], where only a preliminary draft of these guidelines was available. Consequently, it was decided to review the entire procedure for calculation of methane emissions from animal breeding in accord with the *Good Practice Guidance*. At the present time, only preliminary results of the revised calculation of methane emissions from cattle enteric fermentation are available [13], yielding emission factor values comparable with the *default* values for Western Europe, whereas emission factors for dairy cows according to [13] are even about 10 % higher. A preliminary study, which has been prepared in cooperation with the Czech Agricultural University, assumes that the procedure according to Tier 2 would be used only for cattle, which is by far the predominant source for enteric fermentation in the Czech Republic, while a procedure according to Tier 1 is planned for the other types of animals. Innovated calculation for cattle would be based on Czech zootechnical data (milk production, weight, weight gain for growing animals, type of stabling, etc.) and also statistical data for more detailed classification of cattle, that are available in the Czech Republic. It is assumed that a suitable study of enteric fermentation related to the preliminary work [13] could be prepared by the end of 2003. This should be followed by a similar study of emissions from manure management; however, this constitutes a less important source of methane emissions. In any case, recalculation of the entire emission series is expected only following thorough verification of the calculation procedures. Until all the values are suitably verified, the existing procedure will continue to be used.

7.3 Nitrous oxide emissions

The previous greenhouse gas inventories (to 1995), in accord with the older version of the *IPCC Guidelines* [2], considered only emissions from agricultural soils, where the usual (*default*) mean emission factor was taken as the value 0.0036 kg N-N$_2$O/kg N. According to the older manner of calculation, which also did not clearly specify how to determine the necessary data on the amount of organic and biologically bonded nitrogen in soils from standard statistical data for the calculation, the resultant emissions for the Czech Republic were about 2 kt N$_2$O.

On the basis of new studies (see the references in [1]), a new complex methodology was prepared for calculation of emissions from agriculture which, in addition to the formerly considered emissions from agricultural soils, also includes emissions from animal stables and manure management and also indirect emissions derived from atmospheric deposition and from nitrogenous substances flushed into water courses and reservoirs. Simultaneously, there was a significant increase in the emission factor for determining N$_2$O emissions from agricultural soils to the usual mean value of 0.0125 kg N-N$_2$O/kg N, which should lie within the probability interval (0.0025 to 0.0225) [1]. Some domestic professional studies [3, 11] pointed out that the formerly used emission factor value of 0.0036 was too low for farming under the conditions in this country.

A set of interconnected working documents in EXCEL format were prepared in CHMI for the new approach [1], which has been used for inventories since 1996 [12]. The standard calculation for Tier 1 required the following input information:

- the number of head of farm animals (FAO statistics) (dairy cows, other cattle, pigs, sheep, poultry, horses and goats),

- the annual amount of nitrogen applied in the form of industrial fertilizers,

- the annual harvest of cereals and legumes.

All these data were taken from the Statistical Yearbook of the Czech Republic.

Other input data consists in the mass fraction $X_{i,j}$ of animal excrement in animal category i (i = dairy cows, other cattle, pigs, ...) for various types of excrement management (AWMS - Animal Waste Management System) j (j = anaerobic lagoons, pig manure, solid manure, pasturage, daily spreading in fields, other). Here, it holds that $X_{i,1} + X_{i,2} + ... + X_{i,6} = 1$. For Tier 1, [1] gives only the values of matrix X for typical means of management of animal excrement in Eastern and Western Europe. As we are aware that agricultural farming in the Czech Republic cannot be classified according to this system, we carried out the calculation for both characteristics types of management. The results are given in Tab. 7.5.

Tab. 7.5 Comparison of N$_2$O emissions results in 1997 calculated for various AWMS [Gg N$_2$O]

	Western Europe	Eastern Europe
Manure management	1.52	2.56
Agriculture soils (direct emissions)	8.48	7.89
Grazing animals	2.83	2.30
Indirect emissions (atmospheric deposition)	1.12	0.97
Indirect emissions (leaching)	5.30	4.76
Total N$_2$O	19.26	18.49

It is apparent from Tab. 7.5 that differences in the calculation of N$_2$O for countries in Western and Eastern Europe are not large in relation to the expected error. Nonetheless, we will attempt to find an input matrix X (AWMS) that is characteristics for farming in the Czech

Republic; however, this information is not currently available. The results of calculation with the AWMS outputs from [1] for tables derived for Western Europe, which we consider to be close to the conditions in this country, are listed in the final tables. Other outputs (number of head of animals, application of nitrogen in industrial fertilizers) were, of course, taken from statistical data for the Czech Republic [5].

It is apparent from the table that the greatest contribution is that from agricultural soils. The complete results for the agricultural category are given in the tabular annex.

7.4 Total emissions from agriculture – summary and QA/QC procedures

7.4.1 Activity data and emission factors

Most of the necessary data is available in the Statistical Yearbook for the Czech Republic. This information consists in the number of head of animals at the level of: dairy cows, other cattle, pigs, goats, sheep, horses and poultry. Calculation according to Tier 2 requires more detailed classification of the category other cattle (Tab. 7.2); this distribution was included in the emission factors (see below). Of the activity data, the emissions of N_2O are also greatly affected by the amount of nitrogen applied to the soil in the form of inorganic fertilizers. This information is also available in the Statistical Yearbook.

Methane emissions were calculated in relation to the study [6, 4] and thus constitute national values. As was already mentioned, some emission factors also contain population distribution (category of "other cattle") and must be up-dated from time to time. However, it should again be pointed out that the emission factors for Tier 2 are much lower than the *default* values for Tier 1. This fact has become an object of interest to international inspection authorities and thus constituted a reason for revision of all the calculation procedures (see above). Determination of N_2O emissions from agricultural activities constitutes a complicated and complex calculation where, in addition to emissions factors, other similar parameters are also used. At the present time, calculation is available for Tier 1 using *default* values, where the AWMS values can be considered to be specific for a particular country.

All the necessary data related to activity data and emission values were entered in the CRF forms. Only some supplementary information related to the existing Tier 2 procedure were not available. The input data in the calculation spreadsheets (MS Excel) and the resulting values were formally checked before being inserted to the CRF format.

7.4.2 Emission trends

One of the requirements according to [10] consists in ensuring consistency of trends in time. The trend series seems consistent for methane, where the decrease in emissions for enteric fermentation since 1990 is connected with the decrease in the numbers of animals, especially cattle, while the decrease in emissions derived from manure (especially pig manure) is not as great, as there has been a smaller decrease in the number of head of pigs. It would seem that conditions have stabilized somewhat in agriculture since 1994.

In the on-going introduction of the *Good Practice Guidance* [10], increased attention was paid this year to enteric fermentation, which has led to the decision to revise the existing determination of methane emissions. It was further recommended that current cooperation also be continued with specialized agricultural experts in other areas. In relation to the consistency of the emission series for N_2O, it should be recalled that the results have been calculated in a consistent manner since 1996. The recalculated values for 1990 were given

last year (together with data for 2000); this year, they were supplemented by the results for 1994 and the data for 1992 are expected to be recalculated next year.

Tab. 7.6 CH$_4$ and N2O emission trends in Agriculture

	CH$_4$ emissions [Gg CO$_2$ eq.]]		N$_2$O emissions [Gg CO$_2$ eq.]	
	Enteric fermentation *Key source*	Manure management	Direct emissions (soil + manure) *Key source*	Indirect emissions *Key source*
1990	3 293	1 016	5 192	3 042
1994	2 081	733	3 590	2 056
1996	2 054	756	4 213	2 164
1997	1 951	762	3 980	1 990
1998	1 802	741	3 441	1 950
1999	1 789	741	3 382	1 931
2000	1 701	688	3 290	1 862
2001	1 699	672	3 308	1 912

References

1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

2. *IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1995.

3. Fott P.: *Refining of emission factors for greenhouse gases under the conditions in the Czech Republic*, CHMI Report, "Global Climate Change" Project, Environmental Project No. 310/1/96, Prague 1996. (in Czech)

4. Jelínek A, Plíva P., Vostoupal B.: *Determining VOC emissions from agricultural activities in the Czech Republic,* Report for CHMI, Research Institute of Agricultural Technology, Prague, 1996. (in Czech)

5. *Statistical Yearbook 2001*, CSO, Prague 2001.

6. Dolejš: *Emissions of greenhouse gases in agriculture in the Czech Republic,* Report for PROINCOM Pardubice, Research Institure of Animal Production, Uhříněves, Prague 1994. (in Czech)

7. Tichý M., Voráčková Z., Dvořák P.: *Inventory of emissions of greenhouse gases in the Czech Republic in 1990*, SEVEn, Prague 1995. (in Czech)

8. Fott P., Bláha J., Pecka K.: *Inventories of greenhouse gases in 1990-1993*, CHMI, Report in the framework of the "Global Climate Change" Project, for ME, Ed. J. Pretel, Prague 1995. (in Czech)

9. Fott P., Pretel.J., J.Bláha J., Pecka K.: *Inventories of greenhouse gases in the Czech Republic in 1994 - 1995*, CHMI Report, "Global Climate Change" Project, for ME, Ed. J. Pretel, Prague 1996. (in Czech)

10. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

11. Skořepová I: *Refining of the emission actor for nitrous oxide from agricultural land,* Report for CHMI, Prague 1996. (in Czech)

12. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in the Czech Republic in 1996*, CHMI Report, "Global Climate Change" Project , Environmental Project No. 310/1/97, Prague 1997. (in Czech)

13. Fott P., Hons P., Mudrik Z.: Revised Czech emission inventory of CH$_4$ from enteric fermentation. (preliminary study), presented on the EEA workshop on emissions of GHG from agriculture, Copenhagen, 27-28th February, 2003

8. Forestry (Category 5)

Forests in the Czech Republic are mostly employed for economic purposes and, with the exception of completely neglected areas, do not constitute "primary" forest. Thus, the balance was calculated in this activity category for the category of managed forests of the temperate zone. Calculation of the balance of carbon dioxide emissions and removals in forest management was carried out in the same way as in previous years, based on the knowledge and experience of experts from *Ústav pro hospodářskou úpravu lesů* (ÚHÚL) in Brandýs n/L. This method is based on difference between the total annual augmentation and total annual timber harvest, supported by expert judgments and analysis given by national forest experts in 1994. In principle, the methodology follows an idea of second tier [1], nevertheless some conversion and expansion factors recommended by IPCC has been specified and slightly modified to better reflect current conditions in forest management in the Czech Republic. [2].

The total balance was replenished by an estimate of contributions from:

- afforestation of agricultural land (annually updated),

- timber harvest of trees along water courses and from the group of trees growing outside forests (unchanged data based on an assumption that their contribution to total balance remains roughly constant over years); it is almost negligible compared to an influence of "standard forests" and it covers at most 2 % of the total sectoral balance in emissions and removals.

Assigned emission balance better reflects current conditions in forest management in the the Czech Republic and it has also been found functional in preparation of previous inventories.

A domestic information sources, in particular data from ÚHÚL [3], have been used for an application of Tier 2 level. The methodology used for calculation of 2001 balance is fully consistent with procedures used for inventories 1990, 1994 and 1996 to 2000. Previous data for the 1990 – 1995 were based on Tier 1 method. At present this data are recalculated.

8.1 Carbon dioxide balance

The method used for carbon balance calculation is based on ÚHÚL analyses and detail information both on timber harvest and increments in wood mass. Statistical data given in Tab. 8.1 and emission factors given in Tab. 8.2 have been used. These are at present standardized for calculation of the overall national balance and are not in essential disagreement with the IPCC methodology.

For the purpose of this method, stem-wood is defined as that fraction of trees (i.e. trunk and branches) with diameter of the trunk with bark at a height of 130 cm above the ground exceeds 7 cm. The following assumptions has been used:

- amount of biomass that remains in forest after harvest is approximately constant and all phases of decomposition are presented in the same amount,

- decomposition of humus and underground biomass after harvest is continuously compensated by production of new biomass pulp and consecutive trees (decomposition mechanism is not taken into account),

- broadleaf tree species are harvested mainly in the winter (i.e. after leaves loss) and does not lead to increased carbon release (on the contrary to narrow-leaved species),

- newly afforested areas are equal to areas deforested by special harvest,

- carbon production by annual loss of the assimilation organs equals to annual sink in new assimilation organs.

These assumptions are necessary for model simplification [2], nevertheless they sufficiently reflect national conditions (second assumption is necessary as biomass decomposition in not precisely specified in the model).

Tab. 8.1 Basic statistical data for carbon balance calculation in 1990, 1994 and 1996 – 2001

	Unit	1990	1994	1996	1997	1998	1999	2000	2001
Areas under tree species	*thous. ha*	2 542		2 547	2 547	2 548	2 550	2 552	2 556
Total timber removal without bark	*mil. m³*	13.33	11.95	12.58	13.49	13.99	14.20	14.44	14.37
coniferous	*mil. m³*	12.17	11.16	11.26	11.94	12.25	12.42	12.85	12.68
non-coniferous	*mil. m³*	1,16	0,79	1,32	1,55	1,74	1,78	1,59	1,69
Looses in timber harvest	*%*	~ 15	~ 15	~ 15	~ 15	~ 15	~ 15	~ 15	~ 15
Total augmentation yearly	*mil. m³*	17.00	17.90	18.01	18.2	18.4	18.8	19.8	20.00
Cleaning total	*thous. ha*	51.0	43.0	46.0	51.7	50.8	49.3	47.7	49.7
Afforestation after timber removal	*ha*	34 523	27 715	28 426	16 705	20 753	25 770	25 289	21 858
Share of coniferous on removal	*%*	91.3	93.4	89.5	88.5	87.6	87.5	89.2	88.2
Share of coniferous in forests	*%*	78.9	78.3	76.9	78.0	76.7	76.6	76.5	77.2
Afforestation of agriculture land	*ha*	0	299	650	433	403	493	908	1 091
Destroyed by forest fires	*ha*	N/A	807	N/A	195	1 132	336	375	87
Natural regeneration	*ha*	908	818	1 874	2 538	2 663	2 605	3 422	2944

Carbon dioxide emission and sinks balance calculation can be split into three individual parts:

*1. **Carbon dioxide emission and sinks balance based on total annual biomass timber harvest and augmentation from forest management.***

Basic data for carbon dioxide production calculation from major harvest is total timber removal (mil. m³ without bark). Conversion coefficients have been used for wood with bark, topwood and assimilatory organ biomass calculations. Balance is completed by carbon dioxide production calculation of topwood, stump, bark and assimilatory organ biomass from cleaning. Non-registered looses during timber harvest, which were evaluated as 15 % of total annual timber removal [2] (about one half is burned on site) are included into calculation.

Calculation of carbon dioxide sink by biomass augmentation was based on detailed national inventory of wood-biomass reserve (thous m³ without bark), carried out by ÚHÚL experts. Additional input of stump and topwood biomass, assigned by conversion factors, has been added.

An increase of sinks in forest management is given, in particular, by:

- general grow old of forests,
- increase of afforested areas
- gradual and slowly improving of forest health condition.

Tab. 8.2 Conversion coefficients used for balance calculations

Parameter		coefficient
Conversion for mass of timber without bark / mass of timber with bark		1,1
Conversion for content of wood with bark / dry mass	standard timber removal	0.465 t/m^3
	major harvest	0.41 t/m^3 *
Conversion for content of wood with bark / dry mass	non-coniferous	0.65 t dry matter/m^3
	coniferous	0.45 t dry matter/m^3
Conversion for topwood mass / mass of timber with bark	thinning	0.1782
	major harvest	0.0686
	average	0.1003
Conversion stump mass / mass of timber with bark		0.018
Average mass of coniferous assimilatory organ dry material		18 t/ha
Carbon content in dry material		0.45 t C/t dry matter
Average removal in cleaning		3 m^3/ha
Percentage of cleaning on total mass		15 %

* value is lower than generally recommended as during pollution type of timber harvest also dead and withered trees are harvested

2. Carbon dioxide emission and sinks balance based on total annual biomass harvest and augmentation from trees along water courses and from the group of trees growing outside of forests

The latest ÚHÚL 1976 data were used for an estimation of carbon dioxide from timber harvest along watercourses and from the group of trees growing outside of forests. More recent information is not available; nevertheless, it could be assumed that differences from current conditions are less than 20 %. As estimates from this group of trees contributes to overall sectoral balance by less than 2 %, any inaccuracies could be only on the level of tenths of percentage units.

3. Carbon dioxide sinks from afforestation of agricultural land calculation

Input data for carbon dioxide sink calculation from afforestation of agriculture land are based on the Ministry of the Agriculture information on an area of afforested land and related rendered subsidies. Area of afforested land has been multiplied by related conversion factors (7,5 t dry mass / ha for non-coniferous, 5,5 t dry mass / ha for coniferous and factor 0,45 t C / t dry mass).

Tab. 8.3 summarizes results of carbon dioxide emissions and sinks. Carbon removals slightly exceed its in the overall balance, and national forests acts as a little sink for carbon dioxide, which could reflect an acceptable level of national forest management and, generally, gradual regeneration of Czech forests.

8.2 Emissions from wood burning

According to [2], it is assumed that about 7% of major harvesting is burned in the open land. The amount of related emitted gases is not very important and it is added only for the sake of completeness. A similar approach has been used also in the energy category for calculation of emissions from burning wood in stoves or other heating units. To avoid double counting, an amount of carbon dioxide released during such combustions has not been included into total balance, according to the IPCC methodology. Standardized methodology and emission factors [1] have been used for CH_4, CO and NO_X estimates. The results of the balance for 1990, 1994 and 1996 - 2001 are given in Tab. 8.4. According to ÚHÚL estimates, thinning areas are more or less constant in last 5 years.

Tab. 8.3 Overview of total CO$_2$ emissions and removals from LUCF category in 1990, 1994 and 1996-2001 [Gg CO$_2$]

	1990	1994	1996	1997	1998	1999	2000	2001
Total CO$_2$ emissions from forestry	15 132	13 486	13 796	13 833	14 916	15 677	16 070	15 932
Total CO$_2$ emissions from wood removal in other vegetation	371	371	371	371	371	371	371	371
Total sum of CO$_2$ emissions	*15 503*	*13 857*	*14 167*	*14 204*	*15 287*	*16 048*	*16 441*	*16 304*
Total CO$_2$ removals from forestry	17 161	18 071	18 182	18 374	18 576	18 980	19 984	20 191
Total CO$_2$ removals from afforestation of agriculture land	6	3	7	5	4	5	10	12
Total CO$_2$ removals from other vegetation growth	464	464	464	464	464	464	464	464
Total CO$_2$ removals	*17 631*	*18 538*	*18 653*	*18 843*	*19 044*	*19 449*	*20 458*	*20 667*
Total balance of CO$_2$ *(emissions minus removals)*	**-2 128**	**-4 681**	**- 4 486**	**- 4 639**	**-3 757**	**-3 401**	**-4 016**	**-4 363**

Tab. 8.4 Other gas emissions from on-site biomass combustion from wood removal [t]

	1990	1994	1996	1997	1998	1999	2000	2001
CH$_4$	2 364	1 913	2 310	2 250	2 250	2 580	2 360	2 587
CO	20 688	16 738	20 210	19 650	19 650	22 560	20 687	22 635
N$_2$O	2	1	2	2	2	2	2	2
NO$_X$	43	35	42	41	41	47	43	47

8.3 Emissions from liming

Pursuant to requirements of revision and review of national inventory, an estimate of carbon dioxide emissions from liming has been newly provided. In the forest management 25 671 t of dolomite (emission factor 130 t C / kt) and in agriculture 212 000 t of lime or limy material (emission factor 120 t C / kt) were applied. Total emissions from liming can be estimated as 105,5 kt CO$_2$. To avoid inconsistency of emission trend, relevant values have not been included into emission inventory. They will be included in near future, in parallel with recalculations using the new IPCC LUCF methodology.

8.4 Total emissions from forestry - summary and QA/QC procedures

The inventory from the forestry category in 2001 was prepared using identical methodology, without any change in the calculation system compared to previous years. This category is exceptional, as methodical approaches are currently been analyzed internationally, based on [4]. This document should serve as scientific basis for preparation of new IPCC methodology for LUCF sector, to be complete in 2003.

As carbon dioxide emissions and removals in LUCF category in the Czech Republic have only minor contribution to total GHG emission balance, national experts do not consider being rational to include any nonstandard and premature changes at this point in time. After completion and approval of new IPCC methodology for LUCF category, all time series will be recalculated as soon as possible.

References

1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

2. Henžlík, V., Zatloukal V. et al.: *Estimate of overall emissions of greenhouse gases in forest management in the Czech Republic,* Ministry of Agriculture of CR, Prague 1994. (in Czech)

3. *Henžlík, V., Activity data for the forest management sector for 2000 according to information from IEMF* (communication of October 19, 2001). (in Czech)

4. IPCC Special Report on Land Use, Land Use Change and Forestry, IPCC, 2000.

9. Emissions from Waste (Category 6)

Emissions of greenhouse gases from waste in CR consist mainly of methane emissions from municipal waste landfills and methane emissions from wastewater treatment (industrial and municipal). This category also includes CO_2 emissions from waste incineration and nitrous oxide emissions from wastewater. In relation to the decreased emphasis on this category in previous inventories [1, 2, 5, 9], this category was recently completely revised according to the newest requirements in relation to development of the method in accord with the *Good Practice Guidance* [8]. CHMI cooperated in this study with professional workplaces, in particular with the *Institute for Environmental Science of the Faculty of Sciences at Charles' University* [14], the *University of Chemical Technology* (VŠCHT) [6, 15, 17] and ÚVVP (*Institute for Research and Use of Fuels*) in Prague Běchovice [12]. In the framework of this cooperation, all the emission inventories in this category were recalculated for the entire time series from the reference year of 1990 to the present. At the present time, the role of the *Institute for Environmental Science* has been taken over by the *Center for Environmental Issues of Charles University* (COŽP).

Of the individual subcategories in the category 6, only methane from landfills belongs in the category of *key sources* (see [8]). The contributions to the aggregate emissions are given in Tab. 9.1.

Tab. 9.1 Overview of the most important sources from category 6

	Character of source	Gas	% of total
CH_4 emissions from landfilling	Key source	CH_4	1.1
CH_4 emissions from wastewater handling	-	CH_4	0.4
N_2O emissions from wastewater handling	-	N_2O	0.1
CO_2 emissions from waste incineration	-	CO_2	0.2

9.1 Emissions from solid waste landfills

This category belongs amongst *key sources* and the IPCC methodology recommends that increased emphasis be placed on this source. The main greenhouse gas in this category is methane, which is formed in landfills as part of landfill gas from the anaerobic decomposition of biologically degradable carbon. A certain amount of initial data is required to determine emissions. It is necessary to know the amount of waste deposited in the landfill, the portion of biologically degradable carbon in the waste and other parameters specified for the formation of methane in this country. Similarly to last year, this year's calculations are again based on the national study [14], which can be considered as a Tier 3 approach that, however, does not take into account time trends in national parameters. A new study [12] includes this trend. Both studies and data from the *Czech Environmental Institute* were employed as a basis for a more complex study [14], which forms the basis for the following text.

In order to determine emissions in this category of sources, it is necessary to select a suitable method for calculation of emissions. The IPCC method distinguishes two methodical tiers. These are the basic method - Tier 1 - and the FOD (First Order Decay) method - Tier 2, which includes first-order kinetics. Both methods are based on knowledge of the amount of biologically degradable carbon deposited on the landfill, where the basic method is based on the assumption that the landfill is at steady state. The FOD method should be preferable from

the standpoint of determining the emissions in the individual years. However, in the long term, the two methods become very similar. At the present time, only the basic method (Tier 1) is used for the inventory in CR because of the availability of data.

According to Tier 1, the amount of methane emitted from municipal landfills is given by the formula

$$\text{Methane emissions (Gg } CH_4 \text{ p.a.)} = [(MSW_T * MSW_F * L_0) - R] * (1 - OX)$$

where

$$L_0 \text{ (Gg } CH_4/\text{kg waste)} = MCF * DOC * DOC_F * F * 16 / 12$$

where MSW_T is the total amount of municipal waste generated in the given year, MSW_F is its fraction deposited in the landfill, MCF is the correction factor for methane (=1 for a managed landfill), DOC and DOC_F are the fraction of degradable carbon and the part thereof that is actually degraded, F is the CH_4 content in the landfill gas, R denotes the methane removed by targetted oxidation (recovered), 16/12 is the stoichiometric ratio of methane/carbon and OX is the oxidation factor.

The amount of municipal waste deposited in the landfill was determined on the basis of the ISO database [13], where the relevant values are given in Table 9.2. The calculation took into account the fact that a certain amount of the biogas produced is burned or destroyed by targetted bio-oxidation. The detailed procedure is described in studies [12, 14], where the factors employed are taken from the IPCC methodology [3, 8] in relation to the nationally specific factors as given in refs. [12, 14, 16]. A survey of the parameters required for the calculation is given in Table 9.3.

Tab. 9.2 Solid municipal waste (SMW) production in CR for 1990 –2001 [thous. t SMW]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Solid municipal waste	3 764	3 853	3 944	4 037	4 132	4 229	4 329	4 431	4 535	4 195	4 508	4 294
Landfilling	2 371	2 388	2 484	2 543	2 561	2 621	2 683	2 739	2 804	2 632	2 803	2 575

Tab. 9.3 Overview of parameters for calculation of CH_4 emissions from municipal waste landfills

	IPCC Guidelines [3]	IPCC Good Practice [8]	National specific value [12, 14]
Waste deposition [kg/person/day]	0.54 –1.14	-	0.63 - 0.74
DOC	0.19 – 0.08	-	0.096 –0.08
DOC_F	0.77	0.50 – 0.60	0.60
F	0.5	0.4 –0.6	0.61
MCF	0.4 – 1.0		1.0
OX	0	0-10	0.15

Table 9.4 gives an overall survey of emissions in the time series for 1990 - 2001. A model calculation for 2000 has the following appearance ($MSW_T * MSW_F = 2575$ Gg):

Methane emissions (Gg CH_4 p.a.) = (2575 * 1*0.08 *(16/12)*0.6 * 0.61 – 14.07) * (1 - 0.15)
Methane emissions in 2001 = 73.48 Gg CH_4

Tab. 9.4 CH$_4$ emissions from landfills in 1990-2001 [Gg CH$_4$]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CH$_4$ production	112.9	113.7	116.4	111.7	112.5	115.1	117.8	106.9	109.5	102.8	109.4	100.52
Oxidized (OX)	16.4	16.6	16.9	16.2	16.4	16.7	16.8	14.3	14.5	13.4	14.5	12.97
CH$_4$ recovered	3.25	3.25	3.45	3.45	3.45	3.45	6.03	11.79	13.08	13.36	13.36	14.07
Total emissions	93.2	93.9	96.0	92.0	92.7	94.9	95.0	80.9	81.9	76.0	81.7	**73.48**

9.2 Emissions from wastewater handling

The basic factor for determining methane emissions from wastewater handling is the content of organic pollution in the water. The content of organic pollution in municipal water and sludge is given as BOD$_5$ (the biochemical oxygen demand). BOD is a group method of determination of organic substances and expresses the amount of oxygen consumed in the biochemical oxidation, and is thus a measure of biologically degradable substances. In contrast, COD (chemical oxygen demand) is the amount of oxygen required for chemical oxidation and includes both biologically degradable and biologically nondegradable substances. COD, which is used according to [3] for calculation of methane emissions from industrial wastewater treatment plants, is always greater than BOD.

The current IPCC methodology employs BOD for evaluation of municipal wastewater and sludge and COD for industrial wastewater. The new method is also extended to include determination of emissions from sludge that are primarily the products of various methods of treatment of wastewater and, under anaerobic conditions, may contribute to methane formation and methane emissions.

In the determination of methane emissions from wastewater and sludge, it is necessary to determine the total amount of organic substances contained in them and to determine (estimate) the emission factors for the individual means of wastewater treatment. For this purpose, professional cooperation was undertaken with the *University of Chemical Technology* and a study was carried out [14], supplementing an earlier study [6] and related to new studies [15, 17].

9.2.1 Emissions from municipal wastewater

The basic input data for determining emissions from municipal wastewater are as follows:

- the number of inhabitants

- the pollution produced per inhabitant

- the conditions under which the wastewater is treated.

Calculations for conditions in this country are based on pollution production per inhabitant of 18.25 kg BOD p.a. [3], of which approx. 33% is present in the form of insoluble substances, i.e. is separated as sludge [6, 15]. This is also based on the number of inhabitants connected to the sewers and of the percent of treated wastewater collected in the sewers. Tab. 9.5 gives this amount for the nineteen nineties. According to the *Good Practice Guidance* [8], the maximum theoretical methane production B$_0$ equals 0.25 kg CH$_4$/kg COD, corresponding to 0.6 kg CH$_4$/kg BOD. This data is used to determine the emission factors for municipal wastewater and sludge. In determining the emission factor for sludge, it is necessary to evaluate the technology used to treat the particular sludge and to assign a conversion factor to it - MCF - Methane Conversion Factor - giving the part of the organic material that will be transformed as methane (the remainder to CO$_2$). Refs. [15, 17] (study [17] reflects the latest

developments) give a survey of the nationally specific factors for the ratio of aerobic and anaerobic technologies for the 1990's, given in Tab. 9.6. There is also a certain fraction of wastewater that does not enter the sewer system and is treated on site. For this situation, the IPCC method [3, 8] recommends that separation into wastewater and sludge not be carried out (this corresponds to latrines, septic tanks, cesspools, etc.). The residual wastewater in CR, which does not enter the sewer system, is considered to be treated on site.

Tab. 9.5 Sewer connection and wastewater handling [%]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Sewer connection	72.6	72.3	72.7	72.8	73.0	73.2	73.3	73.5	74.4	74.6	74.8	74.9
Wastewater handling	73.0	69.6	77.8	78.9	82.2	89.5	90.3	90.9	91.3	95.0	94.8	95.5

The calculation was carried out using standard working sheets (*IPCC Guidelines* [3] - *Workbook*), processed in the EXCEL program. A specific example for 2000 is given here. The calculation parameters are given in italics.

Calculation example for 2001

Emissions from municipal wastewater = On-site treatment + Wastewater + Sludge

Wastewater:

Water EF = water EF (aerobic) + water EF (septic tanks) + water EF (non-treated)

Water EF = $0.705*0.05*0.6 + 0.25*0.52*0.6+0.05*0.045*0.6 = 0.0975$ kg CH_4/kg BOD

Water BOD = $10\ 224\ 000*18.25*(1 - 0.330)*0.749 = 93.635$ Gg BOD/year

Formation of methane, water = $0.0975*93.894 = 9.12$ Gg CH_4/year

Sludge:

Sludge EF = sludge EF (aerobic) + sludge EF (anaerobic)

Sludge EF = $0.2*0.1*0.6+0.8*0.5*0.6 = 0.252$ kg CH_4/kg BOD

Sludge BOD = $10\ 224\ 000*18.25*0.330*0.749 = 46.118$ Gg BOD/year

Formation of methane, sludge = $0.252*46.118 = 11.62$ Gg CH_4

CH_4 recovered (combusted) = $46.118*0.6*0.5*0.6 = 11.06$ Gg CH_4

On-site treatment:

On-site treatment EF = $0.15*0.6 = 0.09$ kg CH_4/kg BOD

On-site treatment BOD = $2\ 566\ 000*18.25 = 47\ 213$ Gg BOD/year

Formation of methane, on-site treatment = $46.833*0.09 = 4.22$ Gg CH_4

Methane emissions (municipal wastewater) total = $9.12 + 11.62 – 11.06 + 4.22 = 13.90$ Gg CH_4/year

All methane generated in anaerobic processes for sludge was considered to be burned; the remaining methane was considered to be emitted [15, 17].

Tab. 9.6 Used methane conversion factors (MCF) and share of individual technologies [%] in 1990-2001

	MCF	1990	1993	1996	1999	2001
On-site treatment	0.15	100	100	100	100	100.0
Discharged into rivers	0.05	27	21	10	5	4.5
Aerobic treatment of water	0.05	48	54	65	70	70.5
Anaerobic treatment of water	0.50	25	25	25	25	25.0
Aerobic treatment of sludge	0.10	45	40	35	30	20.0
Anaerobic treatment of sludge	0.50	55	60	65	70	80.0

9.2.2 Emissions from treatment of industrial wastewater

The decisive criterion in determining methane in this case is determination of the amount of pollution. This can be carried out either on the basis of specific production of pollution (the amount of pollution per production unit - kg COD / kg product) and from knowledge of the production, or from the overall amounts of industrial wastewater and from a qualified estimate of their concentrations (in kg COD/m^3). The first method seems more accurate, but it is difficult to obtain all the necessary information on production of the individual commodities. It is even more difficult to obtain data on specific production of wastewater, which are dependent on the technologies employed and are often the subject of business secrecy. Here, we used the procedure from the IPCC methodology [3, 8], based on knowledge of production. The necessary activity data were taken from the material of CSO [11] and the other parameters required for the calculation were taken from the *Good Practice Guidance* [8].

On the basis of information on the total amount of industrial wastewater of 179.600 mil.m^3 [7], it was also possible to determine "unidentified" amount of wastewater (11.65 mil.m^3), which were assigned a concentration of 3 kg COD/m^3. In addition, it was estimated that the amount of sludge equals 10% of the total pollution in industrial water (more was reported in some branches) [15, 17], see Tab. 9.7.

Tab. 9.7 Calculation of COD generated by individual sub-categories 2001

	Production [kt/year]	COD/m^3 [kg /m^3]	Wastewater / t [m^3/t]	Share of sludge [%]	COD of sludge [t]	COD of wastewater [t]
Alcohol production	56	11.00	24.00	0.10	1 497	13 476
Milk and diary production	851	2.70	7.00	0.10	1 609	14 481
Beer and malt	2 342	2.90	6.30	0.10	4 280	38 520
Meat and poultry	531	4.10	13.00	0.25	7 077	21 230
Organic chemicals	216	3.00	67.00	0.10	4 349	39 144
Petrochemical industry	7 000	1.00	0.60	0.10	420	3 780
Plastics and synthetic resin	869	3.70	0.60	0.10	193	1 736
Paper and wood pulp	597	9.00	162.00	0.25	217 792	653 375
Soap and detergents	50	0.85	3.00	0.10	13	116
Starch production	48	10.00	9.00	0.10	440	3 956
Sugar refining	482	3.20	9.00	0.10	1 388	12 493
Textiles (natural)	79	0.90	172.00	0.10	1 234	11 110
Vegetable oils	108	0.85	3.10	0.10	29	258
Fruit, vegetables and juices	128	5.00	20.00	0.25	3 220	9 661
Vine and vinegar	60	1.50	23.00	0.10	209	1 879
Unidentified wastewater	11 651	3.00	1.00	0.10	3 495	31 458
Total					**247 244**	**856 673**

In accord with [8], the maximum theoretical methane production B_0 was considered to equal 0.25 kg CH_4/kg COD.

The calculation of the emission factor for wastewater was based on a qualified estimate of the ratio of the use of individual technologies during the entire recalculated time series. In the future, this ratio will shift towards anaerobic treatment of wastewater and sludge because of the energy advantages of this means of treating wastewater. Tab. 9.8 describes this trend. The conversion factor for anaerobic treatment was taken as 0.06 and, for aerobic treatment, 0.7.

In contrast, a stable ratio is retained for sludge treatment for the entire recalculated series. The calculation of the emission factor for sludge was based on the assumption that 40% is treated anaerobically with a conversion factor of 0.3 and the remaining 60 % by other, especially aerobic methods with a conversion factor of 0.1. Similarly as in the previous case, it is assumed that all the methane from the anaerobic processes is burned (mostly usefully in cogeneration units, as flaring is used less and less and cogeneration technology is financially effective); however, in contrast to municipal water, methane from both sludge and wastewater was included.

Thus, in the calculation of methane emissions, it is sufficient to consider only aerobic processes (where the methane is not burned). Professionals at the *University of Chemical Technology* recommended the conversion factors and other parameters given in this part, see [6, 15].

Tab. 9.8 Parameters for CH_4 emissions calculation from wastewater

	MCF	1990	1993	1996	1999	2001
Non-treated	0.05	29 %	18 %	13 %	12 %	6 %
Aerobic treatment of water	0.06	67 %	73 %	70 %	66 %	66 %
Anaerobic treatment of water	0.70	4 %	8 %	17 %	22 %	28 %
Aerobic treatment of sludge	0.10	40 %	40 %	40 %	40 %	30 %
Anaerobic treatment of sludge	0.30	60 %	60 %	60 %	60 %	70 %

Emissions from industrial wastewater for 2001:
Methane emissions from industrial wastewater handling = water EF * water COD + sludge EF * sludge COD – oxidized CH_4
Water EF = water EF (aerobic) + water EF (anaerobic) + water EF (non-treated)
Water EF = 0.66*0.06*0.25 + 0.28*0.70*0.25 + 0.06*0.05*0.25 = 0.0602 kg CH_4/kg COD
Water COD = 856 Gg COD (see Tab. 9.7)
Sludge EF = sludge EF (aerobic) + sludge EF (anaerobic)
Sludge EF = 0.7 * 0.3 * 0.25 + 0.3 * 0.1 * 0.25 = 0.0600 kg CH_4/kg COD
Sludge COD= 247 Gg COD (see Tab. 9.7)
Oxidized methane = 0.28 * 0.70 * 0.25 * 856 + 0.7 * 0.3 * 0.25 * 247 = 55.47 Gg (it's whole methane, which was formed from anaerobic processes)
Methane emissions from industrial wastewater handling = 856 * 0.0602 + 247 * 0.0600 – 55.47 = 10.94 Gg CH_4

Methane emissions from wastewater are not very important because of combustion of methane from anaerobic processes and because of the low value of the conversion factor for aerobic processes (0.05 - 0.06).

9.2.3 Emissions of N_2O from municipal wastewater

Determination of N_2O emissions from municipal wastewater is part of a broader complex of calculations, concerned particularly with the area of agriculture. Tier 1 calculation is based on the number of inhabitants and estimation of the average annual protein consumption. The N_2O emissions according to [3] would then equal

$$N_2O \text{ emissions} = 10\ 224\ 000 * 25 * 0.16 * 0.01 * 44 / 28 / 1\ 000\ 000 = 0.643 \text{ Gg p.a.}$$

The values of 0.16 kg N/kg protein and 0.01 kg N_2O-N/kg N correspond to the mass fraction and standardly recommended emission factor.

9.3 Total emissions from waste - summary

9.3.1 Activity data and other parameters

Inventories of emissions from waste are complicated by the lack of specific data necessary for the calculation, especially in relation to specific national parameters, that are particularly required for evaluating methane emissions from landfills (this is a *key source*). General activity data, e.g. the number of inhabitants connected to sewer lines and the production of selected products, etc., are available in the CSO Yearbook and similar material, but other parameters, for example the content of biodegradable material in the waste, or the type of waste water treatment, are not available in the official statistics. Thus, it is necessary to take into account professional studies and the recommendations of national experts, who are frequently consulted on this matter, see studies [4, 6, 15, 17].

9.3.2 Inventories changes

Since the last inventory, the *Good Practice Guidance* [8] have been gradually introduced. These principles emphasize particularly the consistency of the time series, *key sources* and the transparency of the calculation. Since inventory year 2000 this has led to a number of basic changes in determining the methane emissions from wastes, which then led to recalculation of the entire time series of emissions from this category. Tables 9.4 and 9.9 give the recalculated time series.

Tab. 9.9 CH_4 emissions from municipal and industrial wastewater in 1990-2001 [Gg]

	1990	1994	1996	1997	1998	1999	2000	2001
Municipal wastewater								
CH_4 production	22.34	22.84	23.37	23.36	23.42	23.97	23.95	24.96
Oxidized CH_4	7.47	8.18	8.88	8.89	8.99	9.70	9.69	11.06
Total CH_4 emissions	14.86	14.67	14.49	14.47	14.43	14.27	14.26	13.90
Industrial wastewater								
CH_4 production	49.76	46.67	55.81	58.42	63.33	60.10	63.51	66.42
Oxidized CH_4	25.31	23.86	41.28	43.25	47.00	46.90	50.29	55.47
Total CH_4 emissions	24.45	17.81	14.53	15.16	16.34	13.17	13.26	10.94

Changes in the inventory of **methane emissions from landfills** compared to previous years can be summarized as follows:

- Recalculation of the entire time series using the Tier 1 of the IPCC method, taking into account newly refined values of the national parameters,

- Refining of activity data in relation to the amount of waste landfilled,

- Classification as recovered methane and methane that is intentionally oxidized using biofilters.

Changes in the inventory of **methane emissions from wastewater** consist particularly in:

- For the biological oxygen demand, the value of 0.6 kg CH_4/kg BOD is newly used for maximum methane production, i.e. factor B_0, in accord with [8]; this is more than the value of $B_0 = 0.25$ CH_4/kg BOD, used to date, as this value is valid for COD [8], which is always larger than the corresponding BOD value.

- Refining of the calculation for the area of management of industrial wastewater. In place of the formerly used, less accurate values of the average concentration for industrial wastewater, total COD is now determined on the basis of the production of the individual branches generating wastewater.

- Determination of emissions for the part of the population that is not connected to the public sewer system is now being prepared separately in relation to the different conditions (treatment on site).

In relation to carrying out the recalculation, there has been a relative increase in the fraction of emissions from wastewater and a slight increase in the decreasing trend since 1990. Further details in relation to the newly recalculated results are given in reference [14].

References

1. Fott P., Bláha J., Pecka K.: *Inventories of greenhouse gases in 1990-1993*, CHMI Report for the "Global Climate Change" Project, Environmental Project No. 49/14/1/95, Prague 1995. (in Czech)

2. Fott P., Pretel J., Bláha J., Pecka K., Rábl V.: *Inventories of greenhouse gases in CR in 1994 and 1995*, CHMI Report for the "Global Climate Change II" Project , Environmental Project No. 310/1/96, Prague 1996. (in Czech)

3. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

4. Straka F., Musilová M., Crha J., Pavlas M.: *Emissions of greenhouse gases from wastes in the territory of CR in 1996*, Institute for Research and Use of Fuels, Prague-Běchovice for CHMI, Prague 1997. (in Czech)

5. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in CR in 1996*, CHMI Report for the "Global Climate Change" Project , Environmental Project No. 310/1/97, Prague 1997. (in Czech)

6. Dohanyos M., Zábranská J.: *New method of calculating CH_4 emissions from waste water treatment*. Report for CHMI, Prague 1998. (in Czech)

7. *Environmental Statistical Yearbook of the Czech Republic*. ME CR, Prague 2002. (in Czech)

8. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

9. Fott P., Pretel J., Bláha J., Neužil V.: *Inventory of greenhouse gases in CR in 1998*, CHMI, Prague 1999, CHMI Report, "Global Climate Change" Project, Prague 1999. (in Czech)

10. *Statistical Yearbook 2001*, CSO, Prague 2001.

11. *Production of selected products in industry in CR* (in selected specific units) for January to December 2001, Department of Statistics of Industry, Construction and Energy Production, Czech Statistical Office, Prague 2002. (in Czech)

12. F. Straka: *Calculation of emissions from landfills in CR*, Institute for Research and Use of Fuels, Prague February 2001. (in Czech)

13. ISO Database, Czech Environmental Institute web site, Http://www.ceu.cz. (in Czech)

14. M.Havránek: *Emissions of greenhouse gases from the waste sector in CR*, Thesis. Institute of the Environment, Faculty of Sciences, Charles University and CHMI, Prague 2001. (in Czech)

15. Dohányos M., Zábranská J.: *Proposals for refining the calculation of methane emissions from municipal and industrial wastewater*; Report for CHMI, Prague 2000. (in Czech)

16. Lippert, E: *Standpoint on the aspect of inventories of methane emissions in CR from municipal waste landfills.* Expert report prepared for CHMI, Prague, December 2001. (in Czech)

17. Zábranská J.: *Proposals for refining the calculation of methane emissions from municipal and industrial wastewater (data for years 2000 and 2001)* Report for CHMI, Prague 2002. (in Czech)

10. HFCs, PFCs and SF$_6$ emissions (to Category 3)

This chapter is related to emissions of industrial fluorinated substances, not covered by the Montreal Protocol and affected climate change (hydrofluorocarbons HFCs, perfluorocarbons PFCs and sulfur hexafluoride SF$_6$. These substances, monitored by the UNFCCC and the Kyoto Protocol, are not produced in the CR and national consumption is covered only by import.

They are used in different industrial activities. HFCs are currently used in refrigeration technologies as a cooling medium, where they substitute banned chlorofluorocarbons CFCs and partially regulated halogenated chlorofluorohydrocarbons HCFCs. In some degree, they are used as expanding agents for production of foamed insulating materials, as aerosol (mostly pharmaceutical), cleaning agents in electrotechnical industries and as fire extinguishers (to replace banned halons). PFCs are used in limited amounts in the refrigeration and electrotechnical industries. SF$_6$ is characterized by excellent insulating properties and is thus used primarily as an insulating medium in high-voltage electrotechnology and energy production or for windowpanes insulation.

The *IPCC Guidelines* [2] defines both the potential emissions for Tier 1 inventory and actual emissions for Tier 2 inventory. National inventory is based on the potential emissions method, supplemented by information on F-gases usage in individual branches. Current national legislation does not allow yet preparing an inventory based on actual emission. According to [2], potential emissions are calculated from consumption, defined as the sum of domestic production and imports of substances minus exports and environmentally sound disposal in given year. The method assumes that actual emissions should not exceed potential emissions.

10.1 Potential emissions

As these substances are not nationally produced, import and export information coming from customs authorities are of key importance. Individual F-gases do not have a separate customs code in the customs tariff list as individual chemical substances. SF$_6$ is listed as part of a group of non-metal halogenides and oxides, HFCs and PFCs are given summarily in the group of halogen derivatives of acyclic hydrocarbons. In order to determine the exact amounts of these substances, it is essential to have information from the customs statistics for the individual importers and exporters, the amounts imported and the kinds of substances (mixtures) and possibly also the areas of use. The General Directorate of Customs provided information on imports and exports in 2001. The data collection for 2001 significantly improved due to amended Air Act (86/2002 Coll.) entering into force. It was possible to submit the questionnaire to all importers of F-gases and ask them for additional information on quantity, composition and usage of gases. Such verification procedure can also eliminate possible administrative mistakes or omissions, which could occur during customs process. This approach has been used for preparation of inventories 1995, 1996, 2000 and 2001. For 1997 to 1999, when the only information was the total amount of substances imported in a certain group of substances of the customs code, the calculation were carried out analogous to 1996. For 1999 the calculation was also checked using questionnaires sent to the assumed importers and users.

Tables 10.1 and 10.2 give the results of these analysis and surveys. The total potential emissions of industrial fluorinated substances in 2001 equaled to 1 282.9 Gg CO_2 eq., of which emissions of HFCs formed 82 %, emissions of SF_6 17 % and emissions of PFCs 1 %.

Tab. 10.1 HFCs, PFCs and SF$_6$ potential emissions in 1995 – 2001 [kt CO_2 eq.]

	1995	1996	1997	1998	1999	2000	2001
HFCs	2.2	134.1	295.6	381.8	411.9	674.3	1 045.2
PFCs	0.4	4.2	7.0	9.1	2.7	9.4	14.5
SF$_6$	166.8	183.1	323.1	131.7	110.9	205.9	223.2
Total	169.4	321.4	625.7	522.6	525.5	889.8	1 282.9

Tab. 10.2 HFCs, PFCs and SF$_6$ potential emissions from individual subcategories in 1995-2001 [kt CO_2 eq.]

	1995	1996	1997	1998	1999	2000	2001
Electrical equipment	166.8	154.4	272.4	111.8	49.9	103.6	135.0
Window isolation	0	28.7	50.7	19.8	16.7	58.5	7.5
Semiconductor manufacture	0	0	0	0	45.1	46.5	87.7
Fire extinguishers	0.4	1.3	-	-	3.4	3.27	26.9
Foam blowing and aerosols	0.1	57.0	138.6	38.2	7.0	25.8	29.9
Refrigeration	2.1	80.4	164.0	352.1	403.4	652.2	996.0

An increase in HFCs consumption (esp. of the 134a type and, in refrigeration mixtures, also 143a and 125) is caused by their use as a replacement for banned CFCs and regulated HCFCs in the refrigeration industry. It can be assumed that their consumption will continue to increase. In the other areas of use (expanders, propellants in aerosols, fire extinguishers), HFCs will be used in only minimal amounts and will thus have little effect on the overall inventory of GHG emissions. HFC-134a used mainly in the refrigeration industry has greatest importance of HFC substances. Other substances are used as additives in azeotropic refrigeration mixtures to improve thermodynamic properties of refrigerants. HFC-277ea was newly imported in 2001.

PFCs consumption is increasing in the CR. However, the absolute amounts are very small; substantial increase in the future is not expected. It consists mainly of PFCs admixtures used in refrigeration and in electrotechnology. SF_6 consumption varies over the years. Areas of usage remain unchanged with predominant use in electrotechnology and increased use for windowpanes insulation.

Table 10.3 gives the potential emissions of industrial fluorinated substances in 2001 as individual chemical substances.

10.2 Summary and QA/QC procedures

HFCs and PFCs consumptions are increasing in the CR. However, the absolute amounts of PFCs are relatively very small and are not expected to increase substantially in the future. The consumption of SF_6 varies over the years. The most important substances in category of F-gases are hydrofluorocarbons. Since 1995 their consumption increased from 2,2 t / year to 1 045 t / year. However, there was significant change in the fractions of the individual groups in the total emissions of F-gases (see Table 10.4).

Tab. 10.4 Structure of HFCs, PFCs and SF$_6$ potential emissions in 1995 – 2001 [%]

	1995	1996	1997	1998	1999	2000	2001
HFCs	1.30	41.72	47.24	73.06	78.38	75.80	81.47
PFCs	0.24	1.31	1.13	1.74	0.51	1.06	1.13
SF$_6$	98.47	56.97	51.64	25.20	21.10	23.14	17.40

In the overall evaluation of potential emissions of industrial fluorinated substances at the present time in CR, these substances correspond to 0.9 % of the total emissions of greenhouse gases (See Tab. 11.2). The fraction of these emissions is increasing slowly and could exceed 1% next year because of an increase in absolute emissions of these substances and also because of a decrease in total emissions of greenhouse gases.

In 2001 was accomplished study focused on recalculation and data control for emissions of SF$_6$, HFCs and PFCs [4]. There were studied opportunities for actual emissions calculations, application of this methodology in the CR and General Directorate of Customs data control. Some explanations for differences between current and past values have been found. In most cases questionnaire information significantly improved input data coming from the General Directorate of Customs (comparison of bottom-up and top-down approach). Both approaches give results with maximal difference of 5 %.

The data mentioned above were included by authors of the study [4] into CRF forms (table2(II)s1; table2(II)s2; table2(II).C,E; table2(II).Fs1 and table2(II).Fs2) by the authors of the study [4]. Control of accuracy and completeness of CRF format was performed by the CHMI. Accuracy of the calculations performed in [4] and checked up differences between new and past values was also controlled.

Tab. 10.3 Potential emissions (consumption) in CR in 2001

	Potential emissions [t]	GWP$_{100}$	CO$_2$ eq. [Gg]
SF$_6$	9.34	23 900	**223.23**
CF$_4$	0.28	6 500	1.82
C$_2$F$_6$	0.59	9 200	5.43
C$_3$F$_8$	1.03	7 000	7.21
PFCs total			**14.46**
HFC-23	0.29	11 700	3.39
HFC-32	4.71	650	3.06
HFC-125	64.25	2 800	179.90
HFC-134a	442.00	1 300	574.60
HFC-143a	67.63	3 800	256.99
HFC-152a	2.36	140	0.33
HFC-227ea	1.00	2 900	2.90
HFC-236fa	3.81	6 300	24.00
HFCs total			**1 045.18**
F-gases total			**1 282.87**

References

1. Řeháček V., Michálek L.: *Information on emissions of greenhouse gases containing fluorine in CR in 2001.* Report for CHMI, Prague 2002. (in Czech)

2. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.

3. *Good Practice Guidance and Uncertainty Management in National GHG Inventories*, IPCC 2000.

4. Řeháček V., Michálek L.: *Trends in consumption and emissions of sulfur fluoride, fluroinated hydrocarbons and perfluorinated hydrocarbons affecting climate change in the Czech Republic in 1995 – 1999.* Report for CHMI, Prague 2001. (in Czech)

11. Conclusion

This report provides a survey of the consistency of the time series in previous inventories since 1990. A detailed description of trends in emissions over the longest possible period of time forms a basis for estimation of the limits of the capabilities of CR in international negotiations and for the preparation of realistic predictions of further trends in emissions of greenhouse gases in the territory of CR. Knowledge of trends can also be used in adopting related effective measures for further reduction of emissions, which is very important for countries with transforming economies, where a large amount of the input data used in preparing model predictions changes faster than can be predicted by the models of future of trends.

The inventory of emissions of greenhouse gases for 2001 is logically related to the inventory for 2000. It was prepared using the basic principles of *Good Practice Guidance*; where possible, preference was given to procedures in Tier 2 and Tier 3 using the emission factors determined on the basis of national data and, in other cases, default emission factors recommended by the IPCC methodology.

Tab. 11.1 gives GHG emission values for years 1990, 1994 and 1996 - 2001. The emission values were recalculated using GWP values for the time period of 100 years. More detailed overview is given in the Table annex, which also contains more detail Sectoral Tables for the 2001, taken from the new CRF format. Other tables with supplementary information for control purposes are also available.

Tab. 11.1 Overall results of GHG emissions inventories in 1990, 1994 and in 1996-2001

	1990	1994	1996	1997	1998	1999	2000	2001
CO_2 [mil. t] (emissions & removals)	161.9	125.9	128.3	132.7	124.5	117.7	123.9	123.6
CO_2 emissions only [mil. t]	*164.0*	*130.6*	*132.8*	*137.4*	*128.3*	*121.1*	*127.9*	*128.0*
CO_2 removals only [mil. t]	*-2.1*	*-4.7*	*-4.5*	*-4.6*	*-3.8*	*-3.4*	*-4.0*	*-4.4*
CH_4 [mil. t CO_2 eq.]	16.8	13.0	12.6	12.1	11.4	10.7	10.7	10.5
N_2O [mil. t CO_2 eq.]	11.3	8.3	9.2	8.8	8.4	8.1	8.2	8.3
HFCs, PFCs, SF_6 [mil. t CO_2 eq.]	-	0.2*	0.3	0.6	0.5	0.5	0.9	1.3
Total [mil. t CO_2 eq.]	189.9	147.2	150.4	154.2	144.8	137.0	143.7	143.7
% of 1990	100.0	77.5	79.2	81.2	76.3	72.2	75.7	75.7
Bunkers [mil. t CO_2 eq.]	0.6	0.3	0.5	0.4	0.2	0.5	0.3	0.4

* data for 1995

Overview table shows table that the significant emission reduction compare to reference year 1990 occurred at the beginning of nineties as a result of production and restructuring of national economy after fundamental change in political system. Since 1994, emissions have become more or less stabilized, with an absolute minimum in 1999 (decrease by 27.8 %). The reasons for the short-term emission fluctuations in period of 1995 to 2001 are very difficult to estimate. The temperature changes in winter, temporary competition by production processes with higher energy intensity and gradual removal of price controls for fuel and energy and also changes in the GDP formation could also have affect such changes.

The share of relative contribution of individual greenhouse gases could be seen in Table 11.2. Changes in monitored period are insignificant and they are in range of inventory accurateness.

Following to structure of national energy sector and industrial production, the principal gas is carbon dioxide, whose fraction is above the overall average of the EU countries, while fraction of methane is below this average. The fraction of F-gases currently equals 0.9 % of total aggregated emissions. The expected increase of these substances as a result national policies coming from the Montreal Protocol cannot currently be fully demonstrated, as there is still lack of precise data on import of individual substances.

Tab. 11.2 Relative contributions of single GHGs on the overall aggregated emissions in 1990 and in 1996 - 2001 [%]

	1990	**1994**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
CO_2	85.2	85.6	85.3	86.0	86.0	85.9	86.2	86.0
CH_4	8.8	8.8	8.4	7.8	7.9	7.8	7.5	7.3
N_2O	5.9	5.6	6.1	5.7	5.8	5.9	5.7	5.8
HFCs, PFCs, SF_6	-		0.2	0.4	0.4	0.4	0.6	0.9

The accurateness of emission estimation of individual gases remains at the same level as in last year, equal to following ranges – CO_2 7-10 %, CH_4 35-40 % and N_2O 70-100 %. The accurateness of the overall emission inventory can be estimated at the level of 15 %. These values are reasonably comparable with similar values presented to NIR's of majority of other Parties. The current method of uncertainty estimates, based primarily on an expert judgment, is not fully related to *Good Practice Guidance*. Therefore, it will be necessary to include uncertainty estimates among priorities of the national inventory team for near future.

Abbreviations

APL	*Asociace průmyslových lihovarů* *Association of Industrial Distilleries*
AVNH	*Asociace výrobců nátěrových hmot* *Association of Coatings Producers*
CDV	*Centrum dopravního výzkumu* *Transport Research Centre*
ČHMÚ CHMI	*Český hydrometeorologický ústav* *Czech Hydrometeorological Institute*
ČSÚ CSO	*Český statistický úřad* *Czech Statistical Office*
COŽP	*Centrum pro otázky životního prostředí Univerzity Karlovy* *Center for Environmental Issues of Charles University*
EEA	*European Environmental Agency*
IGU	*International Gas Union*
MŽP (ČR) MoE (CR)	*Ministerstvo životního prostředí (ČR)* *Ministry of the Environment of (CR)*
REZZO	*Registr emisí a zdrojů znečišťování ovzduší* *Register of Emissions and Sources of Air Pollution*
SEVEn	*Středisko pro efektivní využívání energie* *The Energy Efficiency Center*
ÚHÚL	*Ústav pro hospodářskou úpravu lesů* *Forest Management Institute*
SVÚOM	*Státní výzkumný ústav ochrany materiálu*
VŠCHT	*Vysoká škola chemicko technologická* *University (Institute) of Chemical Technology*
ÚVVP	*Ústav pro výzkum a využití paliv* *Institute for Research and Use of Fuels*

Appendix I

EMISSION INVENTORY

2001

TABLE 1 SECTORAL REPORT FOR ENERGY
(Sheet 1 of 2)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO$_2$	CH$_4$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
				(Gg)			
Total Energy	**122 797.75**	**282.07**	**4.98**	**326.96**	**580.65**	**112.69**	**248.41**
A. Fuel Combustion Activities (Sectoral Approach)	**122 246.37**	**14.06**	**4.98**	**326.37**	**580.52**	**112.49**	**245.48**
1. Energy Industries	**59 537.62**	**0.68**	**2.21**	**99.26**	**12.28**	**5.57**	**128.70**
a. Public Electricity and Heat Production	57 393.10	0.61	2.18	96.72	11.69	5.00	125.47
b. Petroleum Refining	1 012.21	0.03	0.00	2.36	0.40	0.19	3.17
c. Manufacture of Solid Fuels and Other Energy Industries	1 132.31	0.04	0.03	0.19	0.20	0.37	0.07
2. Manufacturing Industries and Construction	**34 878.62**	**0.89**	**0.77**	**38.87**	**77.47**	**4.72**	**58.68**
a. Iron and Steel	0.00	0.00	0.00	IE	IE	IE	IE
b. Non-Ferrous Metals	0.00	0.00	0.00	IE	IE	IE	IE
c. Chemicals	0.00	0.00	0.00	IE	IE	IE	IE
d. Pulp, Paper and Print	0.00	0.00	0.00	IE	IE	IE	IE
e. Food Processing, Beverages and Tobacco	0.00	0.00	0.00	IE	IE	IE	IE
f. Other *(please specify)*	34 878.62	0.89	0.77	38.87	77.47	4.72	58.68
Only total of a-e available, treated as f							
3. Transport	**12 061.25**	**2.04**	**1.75**	**129.43**	**292.35**	**60.80**	**4.83**
a. Civil Aviation	130.98	0.00	0.00	9.50	1.80	0.50	0.55
b. Road Transportation	11 285.59	2.02	1.74	110.85	282.73	58.49	4.07
c. Railways	261.55	0.02	0.01	8.20	7.10	1.60	0.20
d. Navigation	31.02	0.00	0.00	0.80	0.70	0.20	0.02
e. Other Transportation *(please specify)*	352.11	0.00	0.00	0.08	0.02	0.00	0.00
Gas pipelines transportation							

TABLE 1 SECTORAL REPORT FOR ENERGY
(Sheet 2 of 2)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
	(Gg)						
4. Other Sectors	**14 580.77**	**10.21**	**0.20**	**19.88**	**157.63**	**30.59**	**51.17**
a. Commercial/Institutional	4 302.05	0.96	0.04	4.95	5.65	1.54	6.58
b. Residential	9 936.44	8.81	0.15	14.41	151.51	28.35	44.29
c. Agriculture/Forestry/Fisheries	342.28	0.44	0.01	0.52	0.47	0.71	0.30
5. Other *(please specify)*[1]	**1 188.11**	**0.25**	**0.05**	**38.94**	**40.79**	**10.82**	**2.10**
a. Stationary	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	IE	IE	IE	IE	IE	IE	IE
b. Mobile	1 188.11	0.25	0.05	38.94	40.79	10.82	2.10
Mobile sources from the Agriculture/Forestry/Fishing Sector are treated here.	1 188.11	0.25	0.05				
B. Fugitive Emissions from Fuels	**551.38**	**268.00**	**0.00**	**0.59**	**0.13**	**0.20**	**2.93**
1. Solid Fuels	**551.38**	**244.74**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
a. Coal Mining	0.00	244.74	NE	NE	NE	NE	
b. Solid Fuel Transformation	IE	IE	IE	IE	IE	IE	IE
c. Other *(please specify)*	551.38	0.00	0.00	0.00	0.00	0.00	0.00
2. Oil and Natural Gas	**0.00**	**23.27**	**0.00**	**0.59**	**0.13**	**0.20**	**2.93**
a. Oil	0.00	0.37		0.59	0.13	0.20	2.93
b. Natural Gas	0.00	22.89				NE	NE
c. Venting and Flaring	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Venting	0.00	0.00				NE	NE
Flaring	0.00	0.00	0.00	NE	NE	NE	NE
d. Other *(please specify)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo Items: [2]							
International Bunkers	**438.94**	**0.13**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**
Aviation	438.94	0.13	0.01	IE	IE	IE	IE
Marine	0.00	0.00	0.00	NO	NO	NO	NO
Multilateral Operations	0.00	0.00	0.00				
CO_2 Emissions from Biomass	**3 124.25**						

[1] Include military fuel use under this category.
[2] Please do not include in energy totals.

TABLE 2(I) SECTORAL REPORT FOR INDUSTRIAL PROCESSES
(Sheet 1 of 2)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO₂	CH₄	N₂O	HFCs⁽¹⁾ P	HFCs⁽¹⁾ A	PFCs⁽¹⁾ P	PFCs⁽¹⁾ A	SF₆ P	SF₆ A	NOₓ	CO	NMVOC	SO₂
	(Gg)					CO₂ equivalent (Gg)					(Gg)		
Total Industrial Processes	**4 524.43**	**3.40**	**3.59**	**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**	**4.78**	**67.91**	**0.46**	**2.48**
A. Mineral Products	**2 000.43**	**0.01**	**0.00**							**1.64**	**1.74**	**0.08**	**0.45**
1. Cement Production	1 789.96												0.12
2. Lime Production	0.00												
3. Limestone and Dolomite Use	NE												
4. Soda Ash Production and Use	0.00												
5. Asphalt Roofing	NE										0.00	NE	
6. Road Paving with Asphalt	0.00									0.03	0.82	0.00	0.02
7. Other *(please specify)*	210.47	0.01	0.00							1.61	0.92	0.08	0.30
Glass production										1.61	0.92	0.08	0.30
B. Chemical Industry	**0.00**	**0.39**	**3.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.68**	**0.03**	**0.29**	**0.31**
1. Ammonia Production	IE	NE								0.33	0.03	0.02	NE
2. Nitric Acid Production			3.32							0.02			
3. Adipic Acid Production			NO							NO	NO	NO	
4. Carbide Production	0.00	0.00									NO	NO	NO
5. Other *(please specify)*	0.00	0.39	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.28	0.31
Sum of other nonspecified items										0.34	0.00	0.28	0.31
C. Metal Production	**2 524.00**	**3.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.33**	**66.10**	**0.08**	**1.66**
1. Iron and Steel Production	2 524.00	2.56								2.02	64.44	0.05	1.52
2. Ferroalloys Production	NE	0.00								0.00	0.00	0.00	0.01
3. Aluminium Production	NO	NO					0.00			NO	NO	NO	NO
4. SF₆ Used in Aluminium and Magnesium Foundries									0.00				
5. Other *(please specify)*	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	1.66	0.03	0.13
Sum of other nonspecified items										0.30	1.66	0.03	0.13

P = Potential emissions based on Tier 1 approach of the IPCC Guidelines. A = Actual emissions based on Tier 2 approach of the IPCC Guidelines. This only applies in sectors where methods exist for both tiers.

⁽¹⁾ The emissions of HFCs and PFCs are to be expressed as CO₂ equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.

TABLE 2(I) SECTORAL REPORT FOR INDUSTRIAL PROCESSES
(Sheet 2 of 2)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
D. Other Production	**0.00**									**0.13**	**0.03**	**0.01**	**0.07**
1. Pulp and Paper										0.13	0.03	0.00	0.07
2. Food and Drink[2]	0.00											0.01	
E. Production of Halocarbons and SF_6				**0.00**		**0.00**		**0.00**					
1. By-product Emissions				0.00		0.00		0.00					
Production of HCFC-22				0.00									
Other				0.00		0.00		0.00					
2. Fugitive Emissions				0.00		0.00		0.00					
3. Other *(please specify)*				0.00		0.00		0.00					
F. Consumption of Halocarbons and SF_6				**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**				
1. Refrigeration and Air Conditioning Equipment				988.40	0.00	7.59	0.00	0.00	0.00				
2. Foam Blowing				0.62	0.00	0.00	0.00	0.00	0.00				
3. Fire Extinguishers				26.90	0.00	0.00	0.00	0.00	0.00				
4. Aerosols/ Metered Dose Inhalers				29.25	0.00	0.00	0.00	0.00	0.00				
5. Solvents				0.00	0.00	0.00	0.00	0.00	0.00				
6. Semiconductor Manufacture				0.00	0.00	6.90	0.00	80.78	0.00				
7. Electrical Equipment				0.00	NE	0.00	NE	134.96	0.00				
8. Other *(please specify)*				0.00	0.00	0.00	0.00	7.46	0.00				
Other - nonspecified								7.46					
G. Other *(please specify)*	**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**

[2] CO_2 from Food and Drink Production (e.g. gasification of water) can be of biogenic or non-biogenic origin. Only information on CO_2 emissions of non-biogenic origin should be reported.

TABLE 3 SECTORAL REPORT FOR SOLVENT AND OTHER PRODUCT USE
(Sheet 1 of 1)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO$_2$	N$_2$O	NMVOC
		(Gg)	
Total Solvent and Other Product Use	**316.88**	**0.69**	**106.73**
A. Paint Application	**124.44**	**NA**	**39.60**
B. Degreasing and Dry Cleaning	**79.69**	**NA**	**25.36**
C. Chemical Products, Manufacture and Processing			**5.91**
D. Other *(please specify)*	**112.75**	**0.69**	**35.87**
(Use of N$_2$O for Anaesthesia)		0.35	NA
(N$_2$O from Fire Extinguishers)		0.00	NA
(N$_2$O from Aerosol Cans)		0.35	NA
(Other Use of N$_2$O)			
Other solvent use (SNAP 0604)	112.75		35.87

Please account for the quantity of carbon released in the form of NMVOC in both the NMVOC and the CO$_2$ columns.

Note: The IPCC Guidelines do not provide methodologies for the calculation of emissions of N$_2$O from Solvent and Other Product Use. If reporting such data, Parties should provide additional information (activity data and emission factors) used to make these estimates in the documentation box to Table 3.A-D.

TABLE 4 SECTORAL REPORT FOR AGRICULTURE
(Sheet 1 of 2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH$_4$	N$_2$O	NO$_x$	CO	NMVOC
			(Gg)		
Total Agriculture	**112.92**	**16.84**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation	**80.89**				
1. Cattle	64.60				
Dairy Cattle	41.67				
Non-Dairy Cattle	22.93				
2. Buffalo	NO				
3. Sheep	0.45				
4. Goats	0.12				
5. Camels and Llamas	NO				
6. Horses	1.23				
7. Mules and Asses	NO				
8. Swine	12.26				
9. Poultry	2.24				
10. Other *(please specify)*	0.00				
B. Manure Management	**32.04**	**1.35**			**0.00**
1. Cattle	2.99				
Dairy Cattle	2.01				
Non-Dairy Cattle	0.98				
2. Buffalo	NO				
3. Sheep	0.02				
4. Goats	0.01				
5. Camels and Llamas	NO				
6. Horses	0.09				
7. Mules and Asses	NO				
8. Swine	28.28				
9. Poultry	0.64				

TABLE 4 SECTORAL REPORT FOR AGRICULTURE
(Sheet 2 of 2)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
			(Gg)		
B. Manure Management (continued)					
10. Anaerobic Lagoons		0.00			NE
11. Liquid Systems		0.19			NE
12. Solid Storage and Dry Lot		0.97			NE
13. Other *(please specify)*		0.18			0.00
		0.18			
C. Rice Cultivation	0.00				**0.00**
1. Irrigated	0.00				NO
2. Rainfed	0.00				NO
3. Deep Water	0.00				NO
4. Other *(please specify)*	0.00				0.00
D. Agricultural Soils [(1)]	**0.00**	**15.49**			**0.00**
1. Direct Soil Emissions	NE	8.36			NE
2. Animal Production	NE	0.96			NE
3. Indirect Emissions	NE	6.17			NE
4. Other *(please specify)*	0.00	0.00			0.00
E. Prescribed Burning of Savannas	**0.00**	**0.00**			
F. Field Burning of Agricultural Residues	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1 . Cereals	0.00	0.00	NO	NO	NO
2. Pulse	0.00	0.00	NO	NO	NO
3 . Tuber and Root	0.00	0.00	NO	NO	NO
4 . Sugar Cane	0.00	0.00	NO	NO	NO
5 . Other *(please specify)*	0.00	0.00	0.00	0.00	0.00
G. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[(1)] See footnote 4 to Summary 1.A of this common reporting format. Parties which choose to report CO_2 emissions and removals from agricultural soils under 4.D. Agricultural Soils category of the sector Agriculture should indicate the amount [Gg] of these emissions or removals in the documentation box to Table 4.D. Additional information (activity data, implied emissions factors) should also be provided using the relevant documentation box to Table 4.D. This table is not modified for reporting the CO_2 emissions and removals for the sake of consistency with the IPCC tables (i.e. IPCC Sectoral Report for Agriculture).

Note: The IPCC Guidelines do not provide methodologies for the calculation of CH_4 emissions, CH_4 and N_2O removals from agricultural soils, or CO_2 emissions from savanna burning or agricultural residues burning. If you have reported such data, you should provide additional information (activity data and emission factors) used to make these estimates using the relevant documentation boxes of the Sectoral background data tables.

TABLE 5 SECTORAL REPORT FOR LAND-USE CHANGE AND FORESTRY
(Sheet 1 of 1)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO$_2$ emissions	CO$_2$ removals	Net CO$_2$ emissions/ removals	CH$_4$	N$_2$O	NO$_x$	CO
			(Gg)				
Total Land-Use Change and Forestry	**16 303.82**	**-20 666.86**	**-4 363.04**	**2.59**	**0.00**	**0.05**	**22.63**
A. Changes in Forest and Other Woody Biomass Stocks	**16 303.82**	**-20 666.86**	**-4 363.04**				
1. Tropical Forests	NO	NO	0.00				
2. Temperate Forests	16 303.82	-20 666.86	-4 363.04				
3. Boreal Forests	NO	NO	0.00				
4. Grasslands/Tundra	NO	NO	0.00				
5. Other (please specify)	0.00	0.00	0.00				
Harvested Wood [1]			0.00				
			0.00				
B. Forest and Grassland Conversion [2]	**0.00**			**0.00**	**0.00**	**0.00**	**0.00**
1. Tropical Forests	NO			NO	NO	NO	NO
2. Temperate Forests	NO			NO	NO	NO	NO
3. Boreal Forests	NO			NO	NO	NO	NO
4. Grasslands/Tundra	NO			NO	NO	NO	NO
5. Other (please specify)	0.00			0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	**0.00**	**0.00**	**0.00**				
1. Tropical Forests	NO	NO	0.00				
2. Temperate Forests	NO	NO	0.00				
3. Boreal Forests	NO	NO	0.00				
4. Grasslands/Tundra	NO	NO	0.00				
5. Other (please specify)	0.00	0.00	0.00				
			0.00				
D. CO$_2$ Emissions and Removals from Soil	**0.00**	**0.00**	**0.00**				
Cultivation of Mineral Soils	NE	NE	0.00				
Cultivation of Organic Soils	NE	NE	0.00				
Liming of Agricultural Soils	NE	NE	0.00				
Forest Soils	NE	NE	0.00				
Other (please specify) [3]	0.00	0.00	0.00				
			0.00				
E. Other (please specify)	**0.00**	**0.00**	**0.00**	**2.59**	**0.00**	**0.05**	**22.63**
On-side burning of Cleared Forest (4)	IE	0.00	0.00	2.59	0.00	0.05	22.63

[1] Following the IPCC Guidelines, the harvested wood should be reported under Changes in Forest and Other Woody Biomass Stocks (Volume 3. Reference Manual, p.5.17).

[2] Include only the emissions of CO$_2$ from Forest and Grassland Conversion. Associated removals should be reported under section D.

[3] Include emissions from soils not reported under sections A, B and C.

[4] CO$_2$ emissions included in A2

Note: See footnote 4 to Summary 1.A of this common reporting format.

TABLE 6 SECTORAL REPORT FOR WASTE
(Sheet 1 of 1)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO$_2$[1]	CH$_4$	N$_2$O	NO$_x$	CO	NMVOC	SO$_2$
				(Gg)			
Total Waste	**357.00**	**98.32**	**0.64**	**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	**0.00**	**73.48**		**0.00**	**0.00**	**0.00**	
1. Managed Waste Disposal on Land	0.00	73.48		NE	NE	NE	
2. Unmanaged Waste Disposal Sites	0.00	0.00		NE	NE	NE	
3. Other *(please specify)*	0.00	0.00		0.00	0.00	0.00	
B. Wastewater Handling		**24.84**	**0.64**	**0.00**	**0.00**	**0.00**	
1. Industrial Wastewater		10.94	NE	NE	NE	NE	
2. Domestic and Commercial Wastewater		9.68	0.64	NE	NE	NE	
3. Other *(please specify)*		4.22	0.00	0.00	0.00	0.00	
C. Waste Incineration	**357.00**	**0.00**	**0.00**	IE	IE	IE	IE
D. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[1] Note that CO$_2$ from Waste Disposal and Incineration source categories should only be included if it stems from non-biological or inorganic waste sources.

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)
(Sheet 1 of 3)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO₂ emissions	CO₂ removals	CH₄	N₂O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF₆ P	SF₆ A	NOₓ	CO	NMVOC	SO₂
	(Gg)				CO₂ equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**127 996.06**	**-4 363.04**	**499.30**	**26.75**	**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**	**331.78**	**671.19**	**219.88**	**250.89**
1. Energy	**122 797.75**		**282.07**	**4.98**							**326.96**	**580.65**	**112.69**	**248.41**
A. Fuel Combustion Reference Approach [2]	124 730.44													
Sectoral Approach [2]	122 246.37		14.06	4.98							326.37	580.52	112.49	245.48
1. Energy Industries	59 537.62		0.68	2.21							99.26	12.28	5.57	128.70
2. Manufacturing Industries and Construction	34 878.62		0.89	0.77							38.87	77.47	4.72	58.68
3. Transport	12 061.25		2.04	1.75							129.43	292.35	60.80	4.83
4. Other Sectors	14 580.77		10.21	0.20							19.88	157.63	30.59	51.17
5. Other	1 188.11		0.25	0.05							38.94	40.79	10.82	2.10
B. Fugitive Emissions from Fuels	551.38		268.00	0.00							0.59	0.13	0.20	2.93
1. Solid Fuels	551.38		244.74	0.00							0.00	0.00	0.00	0.00
2. Oil and Natural Gas	0.00		23.27	0.00							0.59	0.13	0.20	2.93
2. Industrial Processes	**4 524.43**		**3.40**	**3.59**	**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**	**4.78**	**67.91**	**0.46**	**2.48**
A. Mineral Products	2 000.43		0.01	0.00							1.64	1.74	0.08	0.45
B. Chemical Industry	0.00		0.39	3.59	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.03	0.29	0.31
C. Metal Production	2 524.00		3.00	0.00				0.00		0.00	2.33	66.10	0.08	1.66
D. Other Production [3]	0.00										0.13	0.03	0.01	0.07
E. Production of Halocarbons and SF₆						0.00		0.00		0.00				
F. Consumption of Halocarbons and SF₆					1 045.17	0.00	14.49	0.00	223.20	0.00				
G. Other	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

P = Potential emissions based on Tier 1 approach of the IPCC Guidelines.   A = Actual emissions based on Tier 2 approach of the IPCC Guidelines.

[1] The emissions of HFCs and PFCs are to be expressed as CO₂ equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.
[2] For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.
[3] Other Production includes Pulp and Paper and Food and Drink Production.

Note: The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)
(Sheet 2 of 3)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO₂ emissions	CO₂ removals	CH₄	N₂O	HFCs [1] P	HFCs A	PFCs [1] P	PFCs A	SF₆ P	SF₆ A	NOₓ	CO	NMVOC	SO₂
	(Gg)				CO₂ equivalent (Gg)						(Gg)			
3. Solvent and Other Product Use	316.88			0.69							0.00	0.00	106.73	0.00
4. Agriculture	0.00	0.00	112.92	16.84							0.00	0.00	0.00	0.00
A. Enteric Fermentation			80.89											
B. Manure Management			32.04	1.35									0.00	
C. Rice Cultivation			0.00										0.00	
D. Agricultural Soils	(4)	(4)	0.00	15.49									0.00	
E. Prescribed Burning of Savannas			0.00	0.00							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			0.00	0.00							0.00	0.00	0.00	
G. Other			0.00	0.00							0.00	0.00	0.00	NO
5. Land-Use Change and Forestry	(5) 0.00	(5) -4 363.04	2.59	0.00							0.05	22.63	0.00	0.00
A. Changes in Forest and Other Woody Biomass Stocks	(5) 0.00	(5) -4 363.04												
B. Forest and Grassland Conversion	0.00		0.00	0.00							0.00	0.00	NO	
C. Abandonment of Managed Lands	(5) 0.00	(5) 0.00												
D. CO₂ Emissions and Removals from Soil	(5) 0.00	(5) 0.00												
E. Other	(5) 0.00	(5) 0.00	2.59	0.00							0.05	22.63	NE	NE
6. Waste	357.00		98.32	0.64							0.00	0.00	0.00	0.00
A. Solid Waste Disposal on Land	(6) 0.00		73.48										0.00	0.00
B. Wastewater Handling			24.84	0.64							0.00	0.00	0.00	
C. Waste Incineration	(6) 357.00		0.00	0.00							IE	IE	IE	IE
D. Other	0.00		0.00	0.00							0.00	0.00	0.00	0.00
7. Other (*please specify*)	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	0.00

(4) According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO₂ emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables.27) allows for reporting CO₂ emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table8(a) (Recalculation - Recalculated data) and Table10 (Emission trends).

(5) Please do not provide an estimate of both CO₂ emissions and CO₂ removals. "Net" emissions (emissions - removals) of CO₂ should be estimated and a single number placed in either the CO₂ emissions or CO₂ removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

(6) Note that CO₂ from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

SUMMARY 1.A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)
(Sheet 3 of 3)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO₂ emissions	CO₂ removals	CH₄	N₂O	HFCs		PFCs		SF₆		NO_x	CO	NMVOC	SO₂
					P	A	P	A	P	A				
	(Gg)				CO₂ equivalent (Gg)						(Gg)			
Memo Items: [7]														
International Bunkers	**438.94**		**0.13**	**0.01**							**0.00**	**0.00**	**0.00**	**0.00**
Aviation	438.94		0.13	0.01							IE	IE	IE	IE
Marine	0.00		0.00	0.00							NO	NO	NO	NO
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO₂ Emissions from Biomass	**3 124.25**													

[7] Memo Items are not included in the national totals.

SUMMARY 1.B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7B)
(Sheet 1 of 1)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
						P	A	P	A	P	A				
		(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**127 996.06**	**-4 363.04**	**499.30**	**26.75**	**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**	**331.78**	**671.19**	**219.88**	**250.89**
1. Energy		**122 797.75**		**282.07**	**4.98**							**326.96**	**580.65**	**112.69**	**248,41**
A. Fuel Combustion	Reference Approach[2]	124 730.44													
	Sectoral Approach[2]	122 246.37		14.06	4.98							326.37	580.52	112.49	245,48
B. Fugitive Emissions from Fuels		551.38		268.00	0.00							0.59	0.13	0.20	2.93
2. Industrial Processes		**4 524.43**		**3.40**	**3.59**	**1 045.17**	**0.00**	**14.49**	**0.00**	**223.20**	**0.00**	**4.78**	**67.91**	**0.46**	**2,48**
3. Solvent and Other Product Use		**316.88**			**0.69**							**0.00**	**0.00**	**106.73**	**0.00**
4. Agriculture [3]		**0.00**	**0.00**	**112.92**	**16.84**							**0.00**	**0.00**	**0.00**	**0,00**
5. Land-Use Change and Forestry		**0.00** [4]	**-4 363.04** [4]	**2.59**	**0.00**							**0.05**	**22.63**	**0.00**	**0.00**
6. Waste		**357.00**		**98.32**	**0.64**							**0.00**	**0.00**	**0.00**	**0,00**
7. Other		**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**	**0,00**
Memo Items:															
International Bunkers		**438.94**		**0.13**	**0.01**							**0.00**	**0.00**	**0.00**	**0,00**
Aviation		438.94		0.13	0.01							IE	IE	IE	IE
Marine		0.00		0.00	0.00							NO	NO	NO	NO
Multilateral Operations		**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0,00**
CO_2 Emissions from Biomass		**3 124.25**													

P = Potential emissions based on Tier 1 approach of the IPCC Guidelines.   A = Actual emissions based on Tier 2 approach of the IPCC Guidelines.

[1] The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.
[2] For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach in document box of Table1.A(c). Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.
[3] See footnote 4 to Summary 1.A.
[4] Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	123 633,02	10 485,27	8 291,34	1 045,17	14,49	223,20	143 692,48
1. Energy	122 797,75	5 923,38	1 544,01				130 265,14
A. Fuel Combustion (Sectoral Approach)	122 246,37	295,36	1 544,01				124 085,73
1. Energy Industries	59 537,62	14,24	684,18				60 236,04
2. Manufacturing Industries and Construction	34 878,62	18,65	239,70				35 136,97
3. Transport	12 061,25	42,79	543,69				12 647,72
4. Other Sectors	14 580,77	214,51	61,98				14 857,26
5. Other	1 188,11	5,17	14,46				1 207,74
B. Fugitive Emissions from Fuels	551,38	5 628,03	0,00				6 179,41
1. Solid Fuels	551,38	5 139,45	0,00				5 690,83
2. Oil and Natural Gas	0,00	488,58	0,00				488,58
2. Industrial Processes	4 524,43	71,41	1 112,60	0,00	0,00	0,00	5 708,44
A. Mineral Products	2 000,43	0,20	0,00				2 000,63
B. Chemical Industry	0,00	8,19	1 112,60	0,00	0,00	0,00	1 120,79
C. Metal Production	2 524,00	63,02	0,00		0,00	0,00	2 587,02
D. Other Production	0,00						0,00
E. Production of Halocarbons and SF_6				0,00	0,00	0,00	0,00
F. Consumption of Halocarbons and SF_6				0,00	0,00	0,00	0,00
G. Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Solvent and Other Product Use	316,88		214,52				531,40
4. Agriculture	0,00	2 371,42	5 220,37				7 591,79
A. Enteric Fermentation		1 698,64					1 698,64
B. Manure Management		672,78	417,97				1 090,75
C. Rice Cultivation		0,00					0,00
D. Agricultural Soils[2]		0,00	4 802,40				4 802,40
E. Prescribed Burning of Savannas		0,00	0,00				0,00
F. Field Burning of Agricultural Residues		0,00	0,00				0,00
G. Other		0,00	0,00				0,00
5. Land-Use Change and Forestry[1]	-4 363,04	54,32	0,62				-4 308,10
6. Waste	357,00	2 064,73	199,22				2 620,95
A. Solid Waste Disposal on Land	0,00	1 543,05					1 543,05
B. Wastewater Handling		521,68	199,22				720,90
C. Waste Incineration	357,00	0,00	0,00				357,00
D. Other	0,00	0,00	0,00				0,00
7. Other (please specify)	0,00	0,00	0,00	1 045,17	14,49	223,20	1 282,86
Consumption of HFCs, PFCs and SF6 (Tier 1)				1 045,17	14,49	223,20	1 282,86
Memo Items:							
International Bunkers	438,94	2,73	4,42				446,09
Aviation	438,94	2,73	4,42				446,09
Marine	0,00	0,00	0,00				0,00
Multilateral Operations	0,00	0,00	0,00				0,00
CO_2 Emissions from Biomass	3 124,25						3 124,25

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	16 303,82	-20 666,86	-4 363,04			-4 363,04
B. Forest and Grassland Conversion	0,00		0,00	0,00	0,00	0,00
C. Abandonment of Managed Lands	0,00	0,00	0,00			0,00
D. CO_2 Emissions and Removals from Soil	0,00	0,00	0,00			0,00
E. Other	0,00	0,00	0,00	54,32	0,62	54,94
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	16 303,82	-20 666,86	-4 363,04	54,32	0,62	-4 308,10

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	148 000,58
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	143 692,48

[a] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.

Appendix II

EMISSION INVENTORY OVERVIEW

FOR 1990, 1994 AND 1996 – 2001*

* HFCs, PFCs, SF$_6$ data for 1995 – 2001

TABLE 10 EMISSIONS TRENDS (CO₂)
(Sheet 1 of 5)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
						(Gg)						
1. Energy	160 080				127 116		129 592	134 166	124 903	118 038	124 960	122 798
A. Fuel Combustion (Sectoral Approach)	160 080				127 116		129 516	133 925	124 486	117 501	124 420	122 246
1. Energy Industries	59 171				55 768		57 818	59 180	58 706	53 848	60 160	59 538
2. Manufacturing Industries and Construction	59 457				44 199		43 867	43 341	35 376	34 156	36 130	34 879
3. Transport	7 275				7 605		9 896	11 392	10 779	12 016	11 110	12 061
4. Other Sectors	34 177				19 544		17 936	20 013	19 624	17 481	17 019	15 769
5. Other												
B. Fugitive Emissions from Fuels	0				0		76	241	417	537	540	551
1. Solid Fuels					0		76	241	417	537	540	551
2. Oil and Natural Gas												
2. Industrial Processes	3 380				2 772		2 479	2 498	2 661	2 362	2 251	4 524
A. Mineral Products	3 380				2 772		2 479	2 498	2 661	2 362	2 251	2 000
B. Chemical Industry												
C. Metal Production												2 524
D. Other Production												
E. Production of Halocarbons and SF₆												
F. Consumption of Halocarbons and SF₆												
G. Other												
3. Solvent and Other Product Use	530				382		352	336	347	336	335	317
4. Agriculture	0				0		0	0	0	0	0	0
A. Enteric Fermentation												
B. Manure Management												
C. Rice Cultivation												
D. Agricultural Soils (2)												
E. Prescribed Burning of Savannas												
F. Field Burning of Agricultural Residues												
G. Other												
5. Land-Use Change and Forestry (3)	-2 128				-4 681		-4 486	-4 639	-3 757	-3 401	-4 016	-4 363
A. Changes in Forest and Other Woody Biomass Stocks	-2 128				-4 681		-4 486	-4 639	-3 757	-3 401	-4 016	-4 363
B. Forest and Grassland Conversion												
C. Abandonment of Managed Lands												
D. CO₂ Emissions and Removals from Soil												
E. Other												
6. Waste	0				357		357	357	357	357	357	357
A. Solid Waste Disposal on Land												
B. Waste-water Handling												
C. Waste Incineration					357		357	357	357	357	357	357
D. Other												
7. Other (please specify)	0				0		0	0	0	0	0	0
Total Emissions/Removals with LUCF (4)	161 862				125 945		128 294	132 718	124 511	117 692	123 886	123 633
Total Emissions without LUCF (4)	163 990				130 626		132 780	137 357	128 268	121 093	127 902	127 996
Memo Items:												
International Bunkers	617				283		459	407	225	539	343	439
Aviation	617				283		459	407	225	539	343	439
Marine												
Multilateral Operations												
CO₂ Emissions from Biomass												

(1) Fill in the base year adopted by the Party under the Convention, if different from 1990.
(2) See footnote 4 to Summary 1.A of this common reporting format.
(3) Take the net emissions as reported in Summary 1.A of this common reporting format. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
(4) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO₂ emissions and removals from Land-Use Change and Forestry.

TABLE 10 EMISSIONS TRENDS (CH₄)
(Sheet 2 of 5)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
					(Gg)							
Total Emissions	**798.26**				**619.44**		**599.72**	**575.50**	**543.83**	**509.10**	**510.21**	**499.30**
1. Energy	**453.38**				**354.48**		**334.63**	**329.72**	**303.75**	**278.68**	**287.18**	**282.07**
A. Fuel Combustion (Sectoral Approach)	59.31				34.92		33.95	31.27	22.51	20.95	19.41	14.06
1. Energy Industries	7.10				6.72		2.57	2.26	2.24	1.66	1.27	0.68
2. Manufacturing Industries and Construction	1.23				1.50		1.03	1.51	1.21	1.28	1.16	0.89
3. Transport	3.07				1.02		3.51	4.29	1.86	1.90	1.92	2.04
4. Other Sectors	47.91				25.69		26.83	23.22	17.19	16.12	15.06	10.46
5. Other												
B. Fugitive Emissions from Fuels	394.07				319.56		300.68	298.45	281.23	257.73	267.77	268.00
1. Solid Fuels	361.90				281.99		268.42	263.47	253.05	228.96	239.00	244.74
2. Oil and Natural Gas	32.17				37.56		32.26	34.98	28.18	28.77	28.77	23.27
2. Industrial Processes	**5.60**				**3.93**		**4.90**	**3.91**	**4.02**	**3.92**	**3.40**	**3.40**
A. Mineral Products					0.01		0.16	0.01	0.00	0.00	0.01	0.01
B. Chemical Industry	0.40				0.39		0.39	0.39	0.39	0.40	0.39	0.39
C. Metal Production	5.20				3.53		4.34	3.51	3.63	3.52	3.00	3.00
D. Other Production												
E. Production of Halocarbons and SF₆												
F. Consumption of Halocarbons and SF₆												
G. Other												
3. Solvent and Other Product Use												
4. Agriculture	**204.19**				**133.97**		**133.83**	**129.11**	**121.13**	**120.50**	**113.76**	**112.92**
A. Enteric Fermentation	155.78				99.09		97.83	92.86	85.83	85.16	81.01	80.89
B. Manure Management	48.41				34.88		35.99	36.25	35.30	35.34	32.75	32.04
C. Rice Cultivation												
D. Agricultural Soils												
E. Prescribed Burning of Savannas												
F. Field Burning of Agricultural Residues												
G. Other												
5. Land-Use Change and Forestry	**2.58**				**1.91**		**2.31**	**2.25**	**2.25**	**2.58**	**2.36**	**2.59**
A. Changes in Forest and Other Woody Biomass Stocks												
B. Forest and Grassland Conversion												
C. Abandonment of Managed Lands												
D. CO₂ Emissions and Removals from Soil												
E. Other	2.58				1.91		2.31	2.25	2.25	2.58	2.36	2.59
6. Waste	**132.51**				**125.15**		**124.06**	**110.51**	**112.70**	**103.42**	**103.51**	**98.32**
A. Solid Waste Disposal on Land	93.20				92.67		95.04	80.87	81.93	75.98	75.98	73.48
B. Waste-water Handling	39.31				32.48		29.02	29.64	30.77	27.43	27.52	24.84
C. Waste Incineration												
D. Other												
7. Other *(please specify)*	**0.00**				**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:												
International Bunkers	**0.18**				**0.08**		**0.16**	**0.12**	**0.07**	**0.16**	**0.10**	**0.13**
Aviation	0.18				0.08		0.16	0.12	0.07	0.16	0.10	0.13
Marine												
Multilateral Operations												
CO₂ Emissions from Biomass												

TABLE 10 EMISSIONS TRENDS (N$_2$O)

(Sheet 3 of 5)

Czech Republic

2001

Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
						(Gg)						
Total Emissions	**36.34**				**26.69**		**29.71**	**28.42**	**27.07**	**26.17**	**26.37**	**26.75**
1. Energy	**4.57**				**3.93**		**4.16**	**4.31**	**4.47**	**4.46**	**4.78**	**4.98**
A. Fuel Combustion (Sectoral Approach)	4.57				3.93		4.16	4.31	4.47	4.46	4.78	4.98
1. Energy Industries	2.08				2.00		1.34	1.29	2.06	1.95	2.16	2.21
2. Manufacturing Industries and Construction	1.27				0.90		0.44	0.43	0.63	0.60	0.65	0.77
3. Transport	0.26				0.56		1.77	1.94	1.41	1.58	1.66	1.75
4. Other Sectors	0.96				0.47		0.61	0.65	0.38	0.33	0.31	0.25
5. Other												
B. Fugitive Emissions from Fuels	0.00				0.00		0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels												
2. Oil and Natural Gas												
2. Industrial Processes	**3.90**				**3.21**		**3.33**	**3.60**	**3.86**	**3.22**	**3.63**	**3.59**
A. Mineral Products												
B. Chemical Industry	3.90				3.21		3.33	3.60	3.86	3.22	3.63	3.59
C. Metal Production												
D. Other Production												
E. Production of Halocarbons and SF$_6$												
F. Consumption of Halocarbons and SF$_6$												
G. Other												
3. Solvent and Other Product Use	**0.66**				**0.69**		**1.00**	**0.60**	**0.71**	**0.69**	**0.69**	**0.69**
4. Agriculture	**26.56**				**18.21**		**20.57**	**19.26**	**17.39**	**17.14**	**16.62**	**16.84**
A. Enteric Fermentation												
B. Manure Management	2.14				1.53		1.55	1.52	1.44	1.44	1.36	1.35
C. Rice Cultivation												
D. Agricultural Soils	24.41				16.68		19.02	17.73	15.95	15.70	15.26	15.49
E. Prescribed Burning of Savannas												
F. Field Burning of Agricultural Residues												
G. Other												
5. Land-Use Change and Forestry	**0.00**				**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks												
B. Forest and Grassland Conversion												
C. Abandonment of Managed Lands												
D. CO$_2$ Emissions and Removals from Soil												
E. Other	0.00				0.00		0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	**0.65**				**0.65**		**0.65**	**0.65**	**0.65**	**0.65**	**0.65**	**0.64**
A. Solid Waste Disposal on Land												
B. Waste-water Handling	0.65				0.65		0.65	0.65	0.65	0.65	0.65	0.64
C. Waste Incineration												
D. Other												
7. Other *(please specify)*	**0.00**				**0.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:												
International Bunkers	**0.02**				**0.01**		**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**
Aviation	0.02				0.01		0.00	0.00	0.01	0.01	0.01	0.01
Marine												
Multilateral Operations												
CO$_2$ Emissions from Biomass												

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF₆)

(Sheet 4 of 5)

Czech Republic
2001
Submission 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Chemical	GWP
							(Gg)								
Emissions of HFCs(5) -	CO₂ equivalent (Gg)						2.21	134.51	295.62	381.78	411.87	674,32	1 045,17	HFCs	
HFC-23							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-23	11700
HFC-32							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-32	650
HFC-41							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-41	150
HFC-43-10mee							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-43-10mee	1300
HFC-125							0.00	0.00	0.00	0.00	0.03	0,05	0,06	HFC-125	2800
HFC-134							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-134	1000
HFC-134a							0.00	0.10	0.23	0.29	0.14	0,26	0,44	HFC-134a	1300
HFC-152a							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-152a	140
HFC-143							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-143	300
HFC-143a							0.00	0.00	0.00	0.00	0.03	0,05	0,07	HFC-143a	3800
HFC-227ea							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-227ea	2900
HFC-236fa							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-236fa	6300
HFC-245ca							0.00	0.00	0.00	0.00	0.00	0,00	0,00	HFC-245ca	560
Emissions of PFCs(5) -	CO₂ equivalent (Gg)						0.35	4.21	7.00	9.10	2.70	9,42	14,49	PFCs	
CF₄							0.00	0.00	0.00	0.00	0.00	0,00	0,00	CF₄	6500
C₂F₆							0.00	0.00	0.00	0.00	0.00	0,00	0,00	C₂F₆	9200
C₃F₈							0.00	0.00	0.00	0.00	0.00	0,00	0,00	C₃F₈	7000
C₄F₁₀							0.00	0.00	0.00	0.00	0.00	0,00	0,00	C₄F₁₀	7000
c-C₄F₈							0.00	0.00	0.00	0.00	0.00	0,00	0,00	c-C₄F₈	8700
C₅F₁₂							0.00	0.00	0.00	0.00	0.00	0,00	0,00	C₅F₁₂	7500
C₆F₁₄							0.00	0.00	0.00	0.00	0.00	0,00	0,00	C₆F₁₄	7400
Emissions of SF₆(5) -	CO₂ equivalent (Gg)						166.82	183.07	323.13	131.69	110.85	205,90	223,20	SF₆	23900
SF₆							0.01	0.01	0.01	0.01	0.00	0,01	0,01		

(5) Enter information on the actual emissions. Where estimates are only available for the potential emissions, specify this in a comment to the corresponding cell. Only in this row the emissions are expressed as CO₂ equivalent emissions in order to facilitate data flow among spreadsheets.

TABLE 10 EMISSION TRENDS (SUMMARY)

(Sheet 5 of 5)

Czech Republic

2001

Submission 2003

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO$_2$ equivalent (Gg)											
Net CO$_2$ emissions/removals	161 862				125 945	0	128 294	132 718	124 511	117 692	123 886	123 633
CO$_2$ emissions (without LUCF) [6]	163 990				130 626	0	132 780	137 357	128 268	121 093	127 902	127 996
CH$_4$	16 763				13 008	0	12 594	12 085	11 421	10 691	10 714	10 485
N$_2$O	11 266				8 275	0	9 211	8 811	8 390	8 111	8 175	8 291
HFCs	0				0	2	135	296	382	412	674	1 045
PFCs	0				0	0	4	7	9	3	9	14
SF$_6$	0				0	167	183	323	132	111	206	223
Total (with net CO$_2$ emissions/removals)	**189 891**				**147 229**	**-**	**150 421**	**154 240**	**144 844**	**137 020**	**143 665**	**143 692**
Total (without CO$_2$ from LUCF) [6]	**192 019**				**151 910**	**-**	**154 907**	**158 879**	**148 602**	**140 421**	**147 681**	**148 056**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	CO$_2$ equivalent (Gg)											
1. Energy	171 018				135 779	0	137 909	142 428	132 666	125 274	132 472	130 265
2. Industrial Processes	4 708				3 849	169	3 936	4 323	4 465	3 968	4 336	6 991
3. Solvent and Other Product Use	734				596	0	662	522	566	551	549	531
4. Agriculture	12 521				8 459	0	9 188	8 681	7 933	7 844	7 542	7 592
5. Land-Use Change and Forestry [7]	-2 073				-4 640	0	-4 437	-4 591	-3 710	-3 346	-3 966	-4 308
6. Waste	2 983				3 186	0	3 163	2 878	2 924	2 729	2 731	2 621
7. Other	0				0	0	0	0	0	0	0	0

[6] The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO$_2$ emissions and removals from Land-Use Change and Forestry.

[7] Net emissions.

Appendix III - Notation keys

The Sectoral and Summary Report Tables summarize final inventory results. The notation shown in the key (see Table) should be used to show where countries believe the identified source is zero (0). Where countries have opted not to estimate (NE) a particular source of each greenhouse gas, this should be shown. Data problems may limit the possibility of separating out each source individually; in this case it is included elsewhere (IE) and this should also be included in the table with a footnote indicating where the emission source/sink has been reported. Finally, countries may report a particular category as not occurring (NO) in their country.

Table - Notification Keys

PART	Partly estimated
ALL	Full estimate of all possible sources
NE	Not estimated
IE	Estimated but included elsewhere
NO	Not occurring
NA	Not applicable
0	Source is estimated to be zero