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

(LAST REPORT: 2000)

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Contents

1. Introduction

Annual monitoring of greenhouse emissions and sinks is one of the obligations following from the *UN Framework Convention on Climate Change* of 1992. 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* [2-7]. Following authorization by *Ministry of the Environment*, the results of these studies were submitted in the prescribed format to the *Secretariat of the Framework Convention* in Bonn, as official national information, and simultaneously also formed the basis for the Second and Third National Communications [8, 9]. At the present time, CHMI prepares inventories of greenhouse gases as part of its obligations as prescribed by its founder (MoE CR).

This study was carried out to prepare an inventory of greenhouse gases in CR for the year 2000 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 prescribed IPCC methodology [10, 11]; its basic principles, latest developments and relation to the *Framework 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 Czech 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. Because of the extent and importance of emissions from the energy industry, this aspect 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 a separate chapter. As a consequence of extension of the methodical requirements and the transition to the new electronic *Common Reporting Format* (CRF) for submitting results to the authorities of the *Framework Convention* (see the FCCC/CP/1999/7 document), the structure of the inventory reports has undergone significant changes since the inventory for 1999, with increased emphasis placed on *key sources* [11]. The last chapter, Chapter 11 is traditionally devoted to an overall summary of the results, discussion of the determined current emission trends and fundamental comparison with previous studies.

The final tables for the individual Sectoral Reports (categories of sources and sinks) and the Summary Tables, giving the emissions of greenhouse gases in the individual categories of sources, were prepared in the prescribed CRF format and are given in the special Annex of Tables. The Sectoral Report gives data for 2000. The Summary and Trend Tables give data for 1990 and 1996-1999.

The inventory was prepared under the cooperation of workers from CHMI (P. Fott - Chapters 2, 3, 5, 7, 9, 10 and J. Pretel - Chapters 1, 8, 10 and 11) and from KONEKO s.r.o. (J. Bláha - Chapter 3, V. Neužil - Chapters 4, 5, 6). These workers would also like to thank other individuals and collectives of workers in CR who provided basic input information for preparation of the inventory of emissions of greenhouse gases in the Czech Republic within the required deadline. In particular, mention should be made of V. Henžlík (ÚHÚL, Brandýs n/L), B. Bernauer, M. Markvart, M. Dohanyos and J. Zábranská (VŠCHT Prague), F. Straka (ÚVVP Běchovice), V. Řeháček, L. Michálek, M. Havránek and D. Vácha.

This year, this report has been translated into English for the first time and this should be seen as part of the regular submission of data for UN FCCC, which encompasses two data sets in CRF electronic form this year. One set contains the data for 2000, while the second corresponds to the data for the reference year of 1990; because of its importance, the latter was converted into CRF and partly revised. At the present time, data for 1990, 1998, 1999 and 2000 are stored in the prescribed CRF form. The data for 1996 and 1997 are available in a form such that conversion to CRF should not entail any great difficulties. In addition, we are planning conversion of data to CRF for 1992 and 1994.

The CRF data sets for 2000 also contain trend tables, which, however, contain only the values for 1990 and for 1996 - 2000. Data for 1991 - 1995 are available, but they are not available in entirely consistent form. It is necessary to complete recalculation of N_2O from Sector 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 sector.

The complete CRF data set for 2000 (including the trend tables) was also provided to EEA (the *European Environmental Agency*) in December of 2001 through the EIONET system. Thus, amongst other things, the Czech Republic complied with its obligations towards EEA in accord with EU Directive 1999/296/EC, amending previous Directive 1993/389/EEC on mechanisms for monitoring emissions of CO_2 and other greenhouse gases.

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2. Inventory Methodology

2.1 Basic Characteristics of IPCC Methodology

A uniform methodology has been prepared for the purpose of compiling national inventories of anthropogenic emissions and removals of greenhouse gases and this continues to be developed. The bodies of the *Framework Convention* appointed the *Intergovernmental Panel for Climate Change* (*IPCC*) to prepare this methodology. The first version of this method was published in 1995 [1]. However, it was reviewed soon afterwards, so that the second version has been in use since 1997 [2].

The IPCC methodology is concerned with greenhouse gases with primary radiation absorption effect: CO_2, CH_4 and N_2O, substances with increased radiation absorption effect containing fluorine: HFCs, PFCs and SF_6, precursors of tropospheric ozone NO_X, NMVOCs and CO, and the aerosol precursor SO_2. In contrast, substances depleting the ozone layer, although they also have radiation absorption effects, are controlled much more closely by the *Montreal Protocol* rather than by the *Framework Convention*, and are thus not even included in the IPCC methodology. It should be recalled that the *Kyoto Protocol*, which is part of the *Framework Convention* and applies to the countries in its Annex I, covers only gases with primary and elevated radiation effect (see below).

The IPCC methodology places the greatest emphasis on determination of emissions of CO_2, which is the most important greenhouse gas. The only anthropogenic source encompassed in the IPCC methodology consists in the combustion of fossil fuels and, to a much smaller degree, the production of cement and the decomposition of limestone and other carbonate minerals unless these are compensated by subsequent sinks (e.g. melting of glass, liming of soil, lime-based sulfur removal, etc.).

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, called the **Reference Approach**, was described in an older version of the IPCC methodology [1] and basically determines the total amount of burned carbon on the basis of the balance calculation of apparent consumption of individual kinds of fuel (e.g. hard coal, petroleum, petrol, natural gas) within the territory of the country 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, called the **Sectoral Approach**, is described in more detail in the newer version of the *IPCC Guidelines* [2] and is based on the actual fuel consumption in the individual sectors (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 the sector or category of sources 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 for CO_2, is connected with a Land Use Change and Forestry. This is connected particularly 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 to constitute 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.

It is necessary to realize in preparing inventories of methane and nitrous oxide that, because of the nature of the most important sources, i.e. 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 of determining emissions (continuous electronic measurement) can be used only exceptionally (e.g. in the production of nitric acid, fluid-bed furnaces). Thus, it is necessary to employ calculations 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.). Especially emission factors or other similar parameters are employed in calculation relationships. Depending on the complexity of the calculation and the kinds of all the emission factors used (generally recommended - *default*, country-specific, site-specific and technology-specific), the approaches described in the IPCC methodology are divided 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 readily 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).

It is apparent that procedures in higher tiers should be more accurate and should correspond better to reality. However, they are more demanding in all aspects, and especially 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 high transparency.

Although the *Kyoto Protocol* has not yet come into force, many of its stricter requirements on national inventories of greenhouse gases are already being implemented. For example, the results of national inventories according to the IPCC methodology are submitted at the prescribed time every year (15 months after the end of the year in question) and in the required *Common Reporting Forma*t - CRF, to facilitate control. The latter was introduced in 2000. This consists in an electronic form containing almost 40 tables of emission data, emission factors, activity data and other indicators. CO_2 emissions are calculated primarily according to the Sectoral Approach; nonetheless, the Reference Approach is also required for reasons of control.

As was already mentioned at the beginning of this Chapter, the *Kyoto Protocol* applies only to greenhouse gases with primary or elevated radiation absorption effect, which are also sometimes denoted as "Kyoto gases". Specifically, these consist of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). The emissions of these gases can be summarily assessed in terms of the total or aggregated emissions of greenhouse gases, which is calculated as the sum of the emissions of the individual gases multiplied by the appropriate conversion coefficients and denoted as GWP (Global Warming Potential). These coefficients correspond to the factor by which the given gas is more effective than carbon dioxide in absorption of terrestrial radiation. The GWP values for basic gases and a time of 100 years are as follows: the value for CO_2 is set equal to 1, for CH_4, 21 and, for N_2O, 310. Emissions of "new greenhouse gases" containing fluorine are very small compared to the basic gases, but their GWP values are 2-4 orders of magnitude larger. The total aggregated emissions that are 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 of the IPCC Methodology

The first version of the IPCC methodology was issued in 1995 [1] (preliminary version in 1994) and this was recommended for the national inventory at the first two conferences of the parties to the *UN Framework Convention on Climate Change*. A revised version was issued in 1997 [2] and was adopted as binding at COP-3 in Kyoto. The revised version introduces a number of improvements; for example, it provides a better description of the sectoral approach in determining CO_2 from combustion of fuels, introduces a new procedure for calculation of N_2O from agricultural activities and an up-dated calculation for methane from waste water, and also outlines new principles for determining emissions of HFCs, PFCs and SF_6. In some cases, it also provides up-dated and refined emission factors.

From the standpoint of the increased requirements following from compliance with the *Kyoto Protocol*, it was found that it was necessary to extend and supplement the revised IPCC methodology, particularly from the standpoint of improving the quality of the inventory and adequate management of the phenomenon of uncertainty - it is not possible to completely eliminate uncertainty, but its detrimental consequences can be reduced as far as possible. On this basis, a new methodical handbook [3] was created at a series of IPCC meetings, entitled *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; in the following text, this handbook will be referred to simply as the *Good Practice Guidance*. It should be recalled that the *Good Practice Guidance* are concerned with “Kyoto gases”, i.e. substances controlled by the *Kyoto Protocol*. This methodical handbook is intended as a supplement to the revised *IPCC Guidelines* [2].

The target of the *Good Practice Guidance* is to assist countries in preparing inventories so that

- wherever possible, emission estimates are neither overestimated nor underestimated,
- the uncertainty in determining the emissions is reduced as far as possible.

Additional *Good Practice Guidance* in national inventories include transparency, suitable documentation, consistency, time series, completeness (sources and sinks), comparability with the inventories of other countries, evaluation of the level and trends in uncertainties, verifiability (QC/QA mechanisms) and the effectiveness of use of expended finances.

Good Practice Guidance can be 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 in finding an unambiguous algorithm that takes into account the local conditions in the given sector to the maximum possible degree in selecting the method or tier, the 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 sector 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 point of view, 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 the Good Practice Guidance in the Czech National Inventory

The *Good Practice Guidance* [3] was approved in May 2000 by the 16th Plenary meeting of the IPCC and in June 2000 by the 12th meeting of SBSTA. It is expected that they will gradually be introduced and that at least two years will be required for complete introduction into inventory practice (in accord with the recommendations of the bodies of the *Framework Convention*).

The CHMI inventories completed so far are mostly based on the methodology according to ref. [2]. Results determined using the older version [1] prior to issuing of the *Revised IPCC Guidelines* (1990 - 1995 data) were retained if no methodological change was involved, or had already been recalculated (methane emissions from coal mining) or are recalculated here (N_2O emissions, methane emissions from waste). In fact, the latter two revisions were or are carried out in the sense of the *Good Practice Guidance* (recalculation of N_2O emissions for the 1991 - 1995 period has not yet been completed).

The inventories of the emissions of greenhouse gases for 1999 and 2000 were carried out according to the gradual introduction of the *Good Practice Guidance*. Because of the great extent of the relevant methodical instructions, this introduction will continue over the next two years. Attention in this inventory was concentrated particularly on identification of *key sources* that will be the target of increased attention throughout the entire process. Emphasis is also placed on consistency of the time series, as only in this way is it possible to properly evaluate existing emission trends.

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 controlled by the *Convention on Long-Range Transboundary Air Pollution* (CLRTAP). In carrying out inventories of these substances, increased attention must be paid to optimum utilization of the REZZO (*Register of Emissions and Sources of Air Pollution*) system, which, however, employs somewhat different categories of sources, outlined in Decree No. 117/1997 Coll. In this case, the team of workers will be required to concentrate on appropriate conversion of data from the REZZO format to IPCC categorization of sources and sinks; this is quite a difficult task.

It is also necessary to point out that an appropriate counterpart to the *Good Practice Guidance* is only now being prepared for the sector Land Use Change and Forestry and will probably be completed by the IPCC panel in 2002. Thus, at the present time, only the methodical instructions given in [2] can be employed.

2.4 Establishing key sources

In general, it can be expected that, from the standpoint of decreasing 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 primary radiation absorption effect.

The *Good Practice Guidance* [3] 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 in CR.

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].

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

	Gas	Emissions [Gg]	% of total	Cumulate [%]
Energy: Stationary Combustion - Solid (CO_2)	**CO_2**	85 143	57.7	57.7
Energy: Stationary Combustion - Gas (CO_2)	**CO_2**	17 884	12.1	69.8
Energy: Mobile Combustion - Road	**CO_2**	10 344	7.0	76.8
Energy: Stationary Combustion - Liquid (CO_2)	**CO_2**	9 909	6.7	83.5
Energy: Fugitive Emissions - Coal Mining (CH_4)	**CH_4**	5 019	3.4	86.9
Agriculture: Direct Emissions N_2O from Soils	**N_2O**	2 868	1.9	88.9
Industrial: Mineral Products - decarbonizing (CO_2)	**CO_2**	2 251	1.5	90.4
Agriculture: Indirect Emissions N2O from Agriculture	**N_2O**	1 863	1.3	91.7
Agriculture: Enteric Fermentation (CH_4)	**CH_4**	1 701	1.2	92.8
Waste: Landfills (CH_4)	**CH_4**	1 596	1.1	93.9
Energy: Mobile Combustion - Off Road incl. Waters	**CO_2**	1 461	1.0	94.9
Industrial: Nitric Acid (N_2O)	**N_2O**	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	CO_2	692	0.5	97.4
Agriculture: Manure Management (CH_4)	CH_4	688	0.5	97.8
Energy: Fugitive Emissions - Oil and Gas (CH_4)	CH_4	604	0.4	98.3
Waste: Wastewater Handling	CH_4	578	0.4	98.6
Energy: Mobile Combustion - Road	N_2O	508	0.3	99.0
Energy: Mobile Combustion - Aircraft	CO_2	438	0.3	99.3
Agriculture: Manure Management (N_2O)	N_2O	422	0.3	99.6
Energy: Stationary Combustion	CH4	362	0.2	99.8
Waste: Wastewater Handling	N_2O	202	0.1	100.0
Energy: Mobile Combustion - Road	CH_4	40	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	N_2O	19	0.0	100.0
Energy: Mobile Combustion - Off Road incl. Waters	CH_4	5	0.0	100.0
Energy: Mobile Combustion - Aircraft	N_2O	3	0.0	100.0
Energy: Mobile Combustion - Aircraft	CH_4	2	0.0	100.0

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.

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

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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 (Sector 1A)

Combustion processes included in sector 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 sector 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 primary greenhouse gases, i.e. CO_2, CH_4 and N_2O, are calculated on the basis of activity data and the emission factors of the fuel combusted. For the other gases (precursors), data on emissions in the individual consumer sectors are taken directly from the corresponding REZZO sections. The results of the inventory, including the activity data, are submitted in the standard CRF format. For primary 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 form, i.e. as solid, liquid and gaseous fuels in the sense of the IPCC definition. In relation to the degree of elaboration of the calculation procedures to date, the required CRF tables could be filled out with one exception, where the 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 Emissions of Primary Greenhouse Gases

3.1.1 Emissions of carbon dioxide

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:

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 sector. **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 then about 1% higher than when using the older 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 sectors 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 sectors (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 for 2000 differ by less than 2% (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 form 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 sector (combustion in industry).

Tab. 3.1 Comparison of CO_2 emissions calculation from the fossil fuel combustion in 1990 and in 1996 - 2000

	1990	1996	1997	1998	1999	2000
Reference approach [Gg]	159 073	129 673	131 386	122 662	115 136	122 116
Sectoral approach [Gg]	160 080	129 380	133 837	124 392	117 159	124 420
Deviation [%]	0.6	0.2	1.8	1.4	1.7	1.9

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 sectors. 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. Thus, in the inventories, emissions derived from coke are calculated in the energy-production sector (combustion in industry), including emissions from the actual metallurgical process (in oxidation of carbon from pig iron in the production of alloys and steel). The calculation is based on the amount of carbon contained in the coke. In this approach, all CO_2 emissions derived from the carbon in fossil fuels is reported in the energy-production sector - combustion processes.

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 13% in 2000. There was a substantial increase in consumption of natural gas.

Tab. 3.2 Total primary energy source in 1990 and in 2000 [PJ]

	1990	2000	Decrease in consumption
Total primary energy supply	1 819.5	1 477.3	342.2
coal	1 252.7	837.1	415.6

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 the 1996 - 2000 period, as can be seen in Tab. 3.3. Comparison with earlier years is not possible, because the inventory calculations in the 1991 to 1995 period were carried out using a somewhat different method [2].

Tab. 3.3 Share of individual sectors on the CO_2 emissions in 1990 and in 1996-2000 [%]

	1990	1996	1997	1998	1999	2000
Energy Industry	37.0	44.7	44.2	47.2	45.9	48.4
Manufacturing industries	37.1	33.9	32.4	28.4	29.2	29.1
Transport	4.5	7.5	8.4	8.6	10.0	8.9
Commercial and services	6.0	4.1	4.8	4.7	4.8	4.4
Residential	13.0	8.5	8.8	9.7	8.7	7.9
Agriculture	2.4	1.3	1.4	1.4	1.4	1.3

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 2000 are basically 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.

3.1.2 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 sectors 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.

The emission factors for solid, liquid and gaseous fuels in the categories of the sources of the IPCC 1A1 to 1A6 methods were determined using data from the REZZO emission database where these emission factors were calculated as the weighted averages. As CH_4 and NMVOCs are not monitored separately in the REZZO database, but rather as a sum that is still denoted as C_XH_Y, the emission coefficients of these gases were considered to consist in a certain part of the emission coefficient for C_XH_Y. On the basis of the information given in the methodical handbook for CORINAIR [8], the fraction of CH_4 was differentiated on the basis of the type of combustion installation and kind of fuel in the range 20 - 70% (the most frequently cited mass ratio is one part of CH_4 to two parts of NMVOCs).

In the transport sector, CH_4 emissions were calculated on the basis of the emission coefficients for methane recommended in the *IPCC Guidelines* ([1], Part 3 - *Reference Manual*). In calculating the methane emissions from the transport sector, it should be pointed out that, in contrast to calculation of CH_4 from stationary sources, activity data are used directly for the individual fuels consumed in the given sector. These consist specifically in gasoline, diesel oil, jet kerosene, natural gas and propane-butane (LPG).

3.1.3 Nitrous oxide emissions

Although N_2O emissions from combustion processes are not amongst *key sources* in CR, 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] and [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 2000, 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 sector 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.

3.1.4 Obtaining activity data

Determination of the activity data on fuel consumption was based on the preliminary energy balance, prepared by KONEKO marketing s.r.o., on the basis of the material published to date by the *Czech Statistical Office* (CSO) and other organizations on trends in energy management in 2000. For these purposes, it is 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 2000 will be published in 2002). The preliminary energy balance for 2000 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 the reference year of 1990 was based on the definitive CSO balance for that year. While definitive data is given here, only information on the source part may be used without difficulties. Data on consumption in the definitive balance are inadequate for the requirements of the emission inventory in the sector method.

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 sector in the individual subsectors, 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 sector. In both cases, calculations for 2000 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 2000 and for the reference year of 1990 (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.

3.2 Emissions from Combustion - Summary

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 primary 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 2000 with the initial year of 1990 indicates a significant decrease in level of emissions of primary 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 definitive balance may be as large as 5% in the individual balanced years.

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.

3.3 Emissions of Precursors

Inventories of precursors of ozone formation (CO, NO_X and NMVOCs) and the precursor of aerosol formation (SO_2) in CRF format do not require the stating of emission factors. The emission values are thus derived directly from data extracted from the REZZO system. The following assignment is used for the individual items:

R1	energy and processing industries
R2	trade and services, agriculture and forestry
R3	the population
R4	transport including mobile sources in agriculture and forestry

Emissions in the R1 category must first be divided according to the manner of formation into emissions from combustion and emissions from technical processes.

As CH_4 and NMVOCs are not monitored separately in the REZZO database, NMVOC emissions were determined as the difference in C_XH_Y emissions after subtraction of CH_4 emissions, calculated in the framework of par. 2.1.2 for primary greenhouse gases.

The resultant values from [10] were taken for emissions from mobile sources (corresponding to category REZZO 4) to determine emissions from highway transport, while emissions from mobile agricultural and forestry machinery (tractors, combines, etc.) were determined using study [11].

Compared to 1990, there was a significant decrease in SO_2 emissions in 2000 to 13% of the original value for 1990.

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4. Fugitive Emissions (Sector 1B)

Mining, treatment and all handling of fossil fuels are a source of fugitive emissions. Of the "Kyoto gases", these consist mainly of emissions of methane and, of precursors, emissions of volatile organic compounds - NMVOCs (petroleum extraction and processing). In CR, emissions of methane from deep mining of hard coal are significant, while methane emissions from surface mining of brown coal and emissions from landfills and gas distribution are also important. Methane emissions from petroleum extraction and processing are less important. Other industrial activities included in this sector are of marginal importance, in respect to both methane emissions and NMVOC emissions. Sector 1B also includes CO_2 emissions from removal of sulfur dioxide from combustion products using limestone.

4.1 Survey of Sources

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

NMVOC emissions are formed primarily from petroleum refining and in storage and handling of petroleum products.

National emission factors [1], [2] and [7] were used in calculating methane emissions in deep hard coal mining; emission factors according to the IPCC method [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 listed sources or their 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-sectors 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 Emissions of Methane from Mining and Post-Mining Coal Treatment

The mining of coal, especially hard coal, is accompanied by the 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 mining of hard coal, the methane is freed from the coal mass and from the surrounding rocks into the mine air and must be removed to the surface to prevent the 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 the nineteen fifties 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 mil. t/year	CH_4 emissions		Emission factors	
		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	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 this 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**
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
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

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

Other areas of deep mining in CR are not important from the standpoint of 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 calculation in Tier 2 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 calculating methane emissions in this location.

In **surface mining**, the escaping methane is not connected with a specific flow of air and thus it is far more difficult to monitor the amount of methane escaping into the air. Consequently, the recommended (*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 Emissions of Methane from Extraction, Storage, Transit Transport and Distribution of Gas

In the 1990's, the gas industry was one of the most dynamically evolving industrial sectors in CR. Natural gas is an important trade commodity and consequently its consumption, transport, distribution, storage and supplementary extraction in the territory of CR 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 perforation of the pipeline,
- 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 CR on the basis of consultations with professionals in the gas industry.

Tab. 4.4 CH_4 emissions from gas processing, transportation and distribution in 2000

	thous. m^3/year	Determination method
Mining, production and processing	345	EF
High pressure pipelines	800	from the REZZO system
Compressor stations	2 822	EF
Underground storage	3 017	EF
Regulatory stations and measurement	5 675	EF
Distribution networks	5 603	EF
Use of gas (number of users)	10 141	EF
Total	**28 402**	

The total emission value given corresponds to about 0.3% of the total consumption of natural gas in CR. 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 Emissions of Methane from Extraction, Refining and Storage of Petroleum

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 cannot 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 Fugitive Emissions of Methane - Summary

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 CR 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 and Oil 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 2000

	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)	14.86	17.7	264	0.67	176.6
*OKR** (Tier 3)	*13.86*	*18.3*	*254*	*0.67*	*169.9*
Ost. (Kladno -Tier 1*)*	*1.0*	*10.0*	*10*	*0.67*	*6.7*
Post-Mining (Tier 1)	14.86	2.3	35	0.67	23.3
*OKR** (Tier 1)	*13.86*	*2.45*	*34*	*0.67*	*22.7*
Ost. (Kladno - Tier 1*)*	*1.0*	*0.9*	*1*	*0.67*	*0.6*
Mining (Tier 1)	46.66	1.15	54	0.67	35.9
Post-Mining (Tier 1)	46.66	0.1	5	0.67	3.1
				Total	**239.0**

* Ostrava-Karviná coal-mining area

Tab. 4.6 Calculation of CH_4 emissions from oil and natural gas in 2000

	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	6.29	5 287	33 247	0.033
Refining		*PJ oil refined*	*kg CH_4/PJ*		
	1 - 2	239.7	1 150	275 617	0.276
Storage		*PJ oil refined*	*kg CH_4/PJ*		
	1	239.7	250	59 912	0.060
				CH_4 from oil	**0.369**
Production/Processing	***GAS***	*PJ gas produced*	*kg CH_4/PJ*		
(domestic production NG)	2	6.94	49 748	345 458	0.345
Transmission & Distribution		*PJ gas consumed*	*kg CH_4/PJ*		
(transit transport, high and low pressure pipeline)	2	1 824.5	13 724	25 039 841	25.040
Other Leakage		*PJ gas consumed*	*kg CH_4/PJ*		
Underground storage	3	60.65	49 748	3 017 015	3.017
				CH_4 from gas	**28.402**

4.5.2 Trends in emissions

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**
Original value	*427*	*381*	*363*	*353*	*338*	*367*					
Present value	361.9	321.0	306.0	298.0	282.0	276.6	268.5	263.5	253.1	229.0	239.0

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
Oil and natural gas	32.2	35.4	35.9	35.3	34.6	38	32	35	28.2	28.8	28.77

In connection with conversion to CRF format, data for 1990 were recalculated on the basis of 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.

4.6 Emissions of Precursors

Precursors of ozone (NO_X, CO, NMVOCs) and aerosols (SO_2) in the monitored categories of sources are generated primarily in processes of treatment of petroleum and in its storage, and also in other handling of petroleum and petroleum products. Emissions of precursors of ozone and SO_2 in the petroleum industry are calculated in the standard manner using emission factors.

The calculated data were compared with the data in the REZZO national emission database. Their usefulness for direct transfer of data is somewhat limited in this case, as they usually separate data on emissions formed in combustion or in a fugitive manner. However, control of the data at least indicates whether the calculated data are higher than the emissions from petrochemical and other industrial plants as reported in the REZZO national emission database.

The emission factors used for determination of NMVOCs from refineries are based on the Annual Report of the UNIPETROL group [11], which constitutes the group of enterprises Česka rafinerská, a.s., Chemopetrol, a.s., Kaučuk, a.s., Benzina, a.s., and Lovochemie, a.s.

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5. Emissions from Industrial Processes (Sector 2)

5.1 Survey of Sources

This sector includes only emissions from actual processes and not from combustion of fuels 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 sector 1A3). It should also be borne in mind that emissions occurring during petroleum refining belong in sector 1B (fugitive emissions).

In respect to emissions of primary 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*, 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 primary greenhouse gases in Sector 2.

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

	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 primary greenhouse gases are minority sources; however, it should be realized that some sources of CO_2 emissions (e.g. the use of coke in blast furnaces, quenching of coke in coke-over batteries or gasification of masout followed by conversion reaction providing hydrogen for the production of ammonia) can, in principle, also be evaluated in this sector. However, in this case these emissions were fully incorporated in sector 1A3 in relation to the compatibility with the Reference Approach for calculation of total CO_2 emissions from combustion, which is included as a whole in Sector 1A. These emissions are also given for illustration in the sector tables for Sector 2; however, they are not included in the sum in this sector to avoid double counting of these emissions.

According to the IPCC or UN FCCC categorization of sources, this sector also includes emissions from the production and use of HFCs, PFCs and SF_6. These substances are not produced in this country. Emissions derived from their use (replacement of substances depleting the ozone layer) are discussed in a separate chapter.

5.2 Emissions of CO_2

The production of cement 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 CR. The same emission factor taken from the *IPCC Guidelines*, i.e. 0.4985 t CO_2/t cement [1], was used for emissions from cement throughout the nineteen nineties. In 2000, CO_2 emissions decreased slightly compared to previous years and equalled 2 040 Gg CO_2.

The production of glass is a somewhat less important source, where CO_2 emissions (211 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 standpoint, 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 (Sector) 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.

5.3 Emissions of N_2O and CH_4

Nitrous oxide emissions in this sector 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 2000 equalled 6.65 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	9.2	1.8	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 [34].

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 CR 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 (figure for 2000), of which approximately one half corresponds to escape of carbonization gas in coke production.

5.4 Industrial Emissions - Summary

5.4.1 Activity data and emission factors

Collection of activity data in this sector 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) data from CSO, where available (i.e. there were more than 3 manufacturers),

b) questions posed to the individual producers,

c) information from the REZZO working 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] and [2]).

5.4.2 Trends in emissions

Tab. 5.3 Emission trends from cement and HNO_3 production

	Emissions of CO_2 [Gg] from cement production	Emissions of N_2O [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	

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 sector, 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_2O 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.

5.5 Emissions of Precursors

The emission inventory of precursors (NO_X, CO, NMVOCs and SO_2) in the area of industrial processes is rather a complex matter [1]. The most detailed data in this category in CR can be obtained from two basic sources, REZZO 1 and the database of the evidence of payments for air pollution. However, in some cases, it is necessary to proceed according to the CORINAIR methodology using the emission factors given in refs. [1] and [3].

The present IPCC inventory for 1999 employs all the available data from the specified sources, especially from the national emission database REZZO 1. The database permits classification as emissions formed in the combustion of fuel for the production of heat for heating purposes and production of electricity, and emissions formed in technical processes using fuel and without fuel. In this way, the entire data set was divided into two basic parts.

Tab. 5.4 Main categories of the REZZO 1 and corresponding emissions of precursors in 2000 [Gg]

	SO_2	NO_X	CO	C_XH_Y
Stationary combustion sources - total	245.9	130.3	210.4	53.8
Technological sources – total	15.7	25.5	142.6	9.3

The data structure in the REZZO database also permits automatic selection of emission and activity data for various categories of sources in the classification of Decree No. 117/97 Coll., or Decree No. 97/2000 Coll. Thus direct data transfer can be carried out for most IPCC categories, e.g. in the category: Production of cement, lime, ammonia, nitric acid, pig iron and steel, ferro-alloys, paper and foodstuffs. In a number of cases, the classification in the REZZO database is more detailed than required by the data structure for the industrial sector in IPCC. For example, emissions can be determined separately for the glass and ceramics industries, for the production of asphalt mixtures, for various processes in inorganic and organic chemistry, for the production of distillates, for beer and wine, etc. These emissions were reported as sums in the relevant categories of Other, or were combined in group categories, e.g. Iron and steel production (including coke production).

In processing the data, an auxiliary table was created in EXCEL format in the SNAP - CORINAIR classification (Selected Nomenclature of Air Pollution Activities), which enables inclusion of activity data and calculation of the relevant emission factors for industrial processes. It is difficult to control these calculated emission factors in the tabulated data, e.g. in the EMEP/CORINAIR Atmospheric Inventory Guidebook [3], as the category SNAP 4 - Industrial processes - contains emissions exclusively without combustion of fuel (emissions from combustion of fuel are listed in categories SNAP 1 and 3). However, the table is very useful for separate records of activity data in more detailed classification that required by IPCC, which seems to be a rational approach, especially from the standpoint of the possibility of monitoring time series for the individual production processes. The individual database subsets from REZZO formed a basis for preparing this table.

The table was further used for conversion of emission data from REZZO to IPCC, as it permitted transfer of the necessary summation in a lucid manner. This is not given in printed form because of its volume, but is available in electronic form.

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6. Emissions from Solvent Use (Sector 3)

This sector 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 CR.

The *IPCC Guidelines* [1] uses the CORINAIR method [2] for processing NMVOC emissions in this sector. 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 form SNAP to IPCC nomenclature

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 2000 for the sector "Solvent Use and Applications" were prepared on the basis of a study prepared by SVÚOM s.r.o. Prague [4] and its updating for 2000.

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 CR in the given year. This balance approach corresponds to the methodology in the energy sector: (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 CR*
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 Solvent Use sector and will be substantially innovated as a consequence of implementation of EC Directive 99/13/EC in the Czech legislation (from June 1, 2002). It will then be possible to employ activity and emission NMVOC data from the REZZO national emission database (by 2004) [5].

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1. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 1-3, IPCC / OECD / IEA, 1997.
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7. Emissions from Agricultural Production (Sector 4)

7.1 Survey of Sources

Emissions of greenhouse gases in agriculture under the conditions in the Czech Republic consist mainly of emissions of methane and emissions of 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). Further 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], in contrast to the earlier version [2], 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* [13] 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 Agriculture sector, including their contribution to aggregated emissions, are given in Tab. 7.1.

Tab. 7.1 Overview of the most important sources from Agriculture sector

	Character of source	Gas	% of total
Direct emissions of N_2O from agriculture soils	Key source	N2O	1.9
Indirect emissions of N_2O from agriculture activities	Key source	N2O	1.3
Enteric fermentation	Key source	CH4	1.2
Manure management	-	CH4	0.5
Manure management	-	N2O	0.3

7.2 Emissions of Methane

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 at the initiative of 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] and [4]. The number of head of animals required for the calculation were taken in both cases 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] and [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 CR does not exceed 10 °C, the values for a cooler climate (< 15 °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

$$EF = 365/ 5.65 * \text{daily food intake} * Y,$$

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 for determining 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 up-dated 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] and [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 ≤ 25% in determining methane emissions from enteric fermentation [10]. Consequently, it would be useful to verify the current procedure in calculating methane emissions from enteric fermentation according to Tier 2 (in cooperation with the domestic agricultural research workers).

7.3 Emissions of Nitrous Oxide

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_2O/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 CR were about 2 kt N_2O.

On a global scale, the annual emissions of nitrous oxide determined on the basis of completed inventories or estimates, were somewhat lower than the value expected from the annual increase in the average concentration of nitrous oxide in the air [10]. 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_2O emissions from agricultural soils to the usual mean value of 0.0125 kg N-N_2O/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 CR.

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 CR 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_2O emissions results in 1997 calculated for various AWMS [Gg N_2O]

	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_2O	19.26	18.49

It is apparent from Tab. 7.5 that differences in the calculation of N_2O 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 CR; 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 CR [5].

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

The *Good Practice Guidance* [13] are based on the calculation according to the revised IPCC Directive, which was presented above, and further elaborate them to encompass the possibility of including national specifics. Full application of this approach would require cooperation with a specialized workplace concerned with agricultural research, which has not yet been carried out.

7.4 Emissions from Agriculture - Summary

7.4.1 Activity data and emission factors

Most of the necessary data is available in the Statistical Yearbook for CR. 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), which is not generally given in the Statistical Yearbook; however, 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 will undoubtedly be of interest to international inspection authorities. 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 factors were entered in the CRF forms. Only some supplementary information related to calculation in Tier 2 could not be determined.

7.4.2 Trends in emissions

One of the requirements according to [13] 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. For N_2O, the values are given only after 1996 and for 1990; the values for the 1991-1995 period have not yet been recalculated. It would seem that conditions have stabilized somewhat in agriculture since 1996.

In relation to gradual introduction of the *Good Practice Guidance* [13], increased attention was paid this year to *key sources* in accord with [13] and it was concluded that cooperation with specialized professionals is necessary. In addition, consistency of the time series was verified and it was concluded that it is necessary to recalculate data for N_2O for the 1991 - 1995 period, or to verify the whole series in accord with [13].

Tab. 7.6 CH_4 emissions trends in the 90's

	CH_4 emissions [Gg CO_2 eq.]		N_2O 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
1991	2 900	1 004	*Calculation only according to old methodology, Recalculation is prepared*	
1992	2 560	981		
1993	2 234	867		
1994	2 096	823		
1995	2 069	848		
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

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8. Forest Management (Sector 5)

Forests in CR 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 sector 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 two tiers based on the knowledge and experience of experts from *Ústav pro hospodářskou úpravu lesů* (ÚHÚL) in Brandýs n/L. The emission balance determined in this way is a better reflection of actual conditions in forest management in CR and has also been found useful in preparing similar inventories in the past.

The balance was supplemented by an estimate of the balance of greenhouse gases from afforestation of agricultural land and from felling of trees along water courses and from the group of trees growing outside of forests. Compared to previous years, the database did not change and continues to be based on the assumption that this item is constant in the balance. It is practically negligible compared with the balance from "classical" forests, as it corresponds to a maximum of 2% of the total sector balance in emissions and removals.

At the level of Tier 1, the procedure according to [1] was employed; Tier 2 will use mainly results from domestic information sources, especially data from ÚHÚL. The methodology of calculation for 2000 is fully consistent with the procedure employed for preparing inventories for 1995 to 1999.

8.1 Carbon Dioxide Balance

Tier 1

The amount of carbon absorbed as a consequence of tree growth in coniferous and broadleaf forests corresponds to the product of the area of the forest [ha], the annual hectare growth in dry wood matter [t dm/ha] and the factor 0.45 t C/t of dry matter (the standard value for the carbon content in dry wood matter (dm), for the climatic and geographic conditions in CR, accepted by ÚHÚL). The values of the total area of forests were taken from the data of CSO or ÚHÚL, which prepared the statistical data.

The amount of carbon contained in total harvested wood biomass from coniferous and broadleaf trees is calculated as the product of felling of the relevant kind of wood [m^3 of timber without bark], the conversion expansion factor and the conversion factor of 0.45 t C/t of dry matter. The conversion expansion factor takes into account, amongst other things, losses in felling, cleaning, amounts of bark, etc. Its value depends to a considerable degree on the type of forest and means of harvesting. A value of 0.68 t dm/m^3 is used for CR; this value was derived from Tier 2 calculations and is somewhat lower than the value recommended by the IPCC methodology. The final amount of carbon that can be emitted from the wood biomass is given in the final tables and the necessary input statistical data for the 1990 and 1996 - 2000 period is given in Tab. 8.1.

For comparison, Tab. 8.2 gives a basic survey of trends in tree felling in the 1990 - 2000 period.

Tab. 8.1 Basic statistical data for carbon balance calculation in 1990 and 1996 – 2000

	Unit	1990	1996	1997	1998	1999	2000
Areas under tree species	*thous. ha*	2 542	2 547	2 547	2 548	2 550	2 552
Total timber removal without bark	*mil. m^3*	13.33	12.58	13.49	13.99	14.20	14.44
coniferous	*mil. m^3*	12.17	11.26	11.94	12.25	12.42	12.85
Looses in felling	*%*	~ 15	~ 10	~ 15	~ 15	~ 15	~ 15
Total augmentation yearly	*mil. m^3*	17.00	18.01	18.2	18.4	18.8	19.8
Cleaning total	*thous. ha*	51.0	46.0	51.7	50.8	49.3	47.7
Afforestation after timber removal	*ha*	34 523	28 426	16 705	20 753	25 770	25 289
Share of coniferous on removal	*%*	91.3	89.5	88.5	87.6	87.5	89.2
Share of coniferous in forests	*%*	78.9	76.9	78.0	76.7	76.6	76.5
Afforestation of agriculture land	*ha*	0	650	433	403	493	908
Destroyed by forest fires	*ha*	N/A	N/A	195	1 132	336	375
Natural regeneration	*ha*	908	1 874	2 538	2 663	2 605	3 422

Tab. 8.2 Timber removal development in 1990 and 1996 - 2000 [thous. m^3 without bark]

	1990	1996	1997	1998	1999	2000
Total timber removal	13 332	12 580	13 490	13 990	14 200	14 441
Coniferous	12 175	11 260	11 942	12 250	12 420	12 851
Non-Coniferous	1 157	1 320	1 548	1 740	1 780	1 590

Tier 2

The second means of balancing carbon in forest management is based on ÚHÚL analyses and on detailed information both on felling and on increments in wood mass. The calculation was carried out using the coefficients given in Tab. 8.3. These are currently standardized for calculation of the overall balance in CR and are not in fundamental contradiction with the IPCC methodology.

Stem-wood is defined as that fraction of trees (i.e. trunk and branches) where the diameter of the trunk, with bark, at a height of 130 cm above the ground is greater than 7 cm. Calculations were carried out under the following working assumptions:

- the amount of biomass that remains in the forest after harvesting is approximately constant and is present in all phases of decomposition in the same amount,
- decomposition of humus and underground biomass following felling is continuously compensated by the formation of new biomass pulp and subsequent forest tree stands,
- the harvesting of broadleaf tree species is carried out mainly in the winter, i.e. after loss of leaves, and does not lead to increased release of carbon, in contrast to narrow-leaved species,
- the area of newly afforested stands equals the average area of special deforestation,
- the carbon production from annual loss of the assimilation organs equals the annual sink in new assimilation organs.

Tab. 8.3 Conversion coefficient

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 major harvest	0.465 t/m^3 0.41 t/m^3
Conversion for content of wood with bark / dry mass	non-coniferous coniferous	0.65 t dry matter/m^3 0.45 t dry matter/m^3
Conversion for topwood mass / mass of timber with bark	thinning major harvest average	0.1782 0.0686 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		10%

The latest ÚHÚL data from 1976 was used for balancing carbon dioxide from tree felling along watercourses and from the group of trees growing outside of forests, where it can be assumed that this does not differ from actual conditions by more than 20%. More up-to-date data are not available; nonetheless, as estimates of emissions and sinks from this group of stands correspond to a maximum of 2% of the sector balance, any inaccuracies can be reflected in the overall sector balance as a maximum of tenths of percentage units.

Tab. 8.4 View of total CO_2 emissions and removals from LUCF in 1990 and 1996-2000 [Gg CO_2]

	1990	**1996**	**1997**	**1998**	**1999**	**2000**
Total CO_2 emissions from forestry	15 132	13 796	13 833	14 916	15 677	16 070
Total CO_2 emissions from wood removal in other vegetation	371	371	371	371	371	371
Total sum of CO_2 emissions	*15 503*	*14 167*	*14 204*	*15 287*	*16 048*	*16 441*
Total CO_2 removals from forestry	17 161	18 182	18 374	18 576	18 980	19 984
Total CO_2 removals from afforestation of agriculture land	6	7	5	4	5	10
Total CO_2 removals from other vegetation growth	464	464	464	464	464	464
Total CO_2 removals	*17 631*	*18 653*	*18 843*	*19 044*	*19 449*	*20 458*
Total balance of CO_2 *(emissions minus removals)*	**-2 128**	**- 4 486**	**- 4 639**	**-3 757**	**-3 401**	**-4 016**

The results of calculation for forest stands in CR are given in the working documents stored at the management workplaces and are summarized in working document 5-2-1 and surveyed in Tab. 8.4. It follows from the values in the table that, in the overall balance, carbon removals slightly exceed emissions. According to this calculation, forests in CR acted as a small sink for carbon dioxide, reflecting the acceptable level of management of forests and their gradual renewal.

8.2 Emissions CH_4, CO and NO_X from Burning of Wood During Felling in Forests

According to [2], it is assumed that about 7% of major harvesting is burned in the open land. The amount of gases emitted during burning this matter at the site of the harvesting is not very important and is given here only for the sake of completeness. A similar approach was adopted in the energy sector in connection with calculation of emissions from burning wood in stoves or other heating units. The amount of carbon dioxide released during combustion, either in situ or in stoves was not included in the total balance, in accord with the IPCC methodology, to avoid double calculation. The results of the balance for the 1995 - 2000 period are given in Tab. 8.5. According to ÚHÚL estimates, the area of thinning practically did not change compared with 1999 and it can thus be assumed for the preliminary balance that the values in 1998 will be practically the same, as is indicated by determination of the changes in 1996 and 1997. This burning is dependent more on major felling than thinning.

Tab. 8.5 Other gas emissions from on-site biomass combustion from wood removal [t]

	1990	1996	1997	1998	1999	2000
CH_4	2 364	2 310	2 250	2 250	2 580	2 360
CO	20 688	20 210	19 650	19 650	22 560	20 687
N_2O	2	2	2	2	2	2
NO_X	43	42	41	41	47	43

8.3 Emissions from Forest Management - Summary

Compared with the inventory from the forest management sector in 2000, there was no methodical or other change in the calculation system in 2001. This sector is unusual in that methodical approaches for determining the balance are currently been analyzed in detail at an international level, where the professional basis was published in [4]. This should become the professional basis for creation of a new methodology for balancing emissions from this activity sector, on which IPCC commenced work in 2001, where work is expected to be completed in 2003.

As the level of carbon dioxide removals in forest management in CR constitutes a minority fraction of the total emission balance of greenhouse gases, the authors do not consider it useful to make any nonstandard, premature changes at this point in time.

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9. Emissions from Waste (Sector 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 sector also includes CO_2 emissions from waste incineration and nitrous oxide emissions from wastewater. In relation to the decreased emphasis on this sector in previous inventories [1, 2, 5 and 9], this sector was 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] and ÚVVP (*Institute for Research and Use of Fuels*) in Prague Běchovice [6, 12]. In the framework of this cooperation, all the emission inventories in this sector were recalculated for the entire time series from the reference year of 1990 to the present.

Of the individual subcategories in the Waste sector, 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 Waste sector

	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 sector belongs amongst *key sources* and the IPCC methodology recommends that increased emphasis be placed on this source. The main greenhouse gas in this sector 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 in 90's [thous. t SMW]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000*
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
Landfilling	2 371	2 388	2 484	2 543	2 561	2 621	2 683	2 739	2 804	2 632	2 803

* preliminary data

Tab. 9.3 Overview of parameters for calculation of CH_4 emissions from municipal waste landfills [16]

	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 - 2000. A model calculation for 2000 has the following appearance ($MSW_T * MSW_F = 2632$ Gg):

Methane emissions (Gg CH_4 p.a.) = (2803 * 1 * 0.08 * 0.6 * 0.61 - 13.36) * (1 - 0.15).

Methane emissions in 2000 = 81.66 Gg CH_4.

Tab. 9.4 CH_4 emissions from landfills in 1990-2000 [Gg CH_4]

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000***
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
Oxidized (OX)	16.4	16.6	16.9	16.2	16.4	16.7	16.8	14.3	14.5	13.4	14.5
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
Total emissions	**93.2**	**93.9**	**96.0**	**92.0**	**92.7**	**94.9**	**95.0**	**80.9**	**81.9**	**76.0**	**81.7**

* preliminary data

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 a new study [15].

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). Ref. [15] gives 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 that 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*
Sewer connection	72.6	72.3	72.7	72.8	73.0	73.2	73.3	73.5	74.4	74.6	74.6
Wastewater handling	73.0	69.6	77.8	78.9	82.2	89.5	90.3	90.9	91.3	95.0	95.0

* preliminary data

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 2000

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 = 0.7*_0.05_*0.6 + 0.25*_0.5_*0.6 + 0.05*_0.05_*0.6 = 0.0975 kg CH_4/kg BOD

Water BOD = 10 278 000*18.25*(1-0.330)* 0.746 = 93.753 Gg BOD/year

Formation of methane, water = 0.0975 *93.789 = 9.14 Gg CH_4/year

Sludge:

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

Sludge EF = 0.3*_0.1_*0.6 + 0.7*_0.5_*0.6 = 0.228 kg CH_4/kg BOD

Sludge BOD = 10 300 000*18.2*0.330*0.746 = 46.199 Gg BOD/year

Formation of methane, sludge = 0.204 *46.199 = 10.52 Gg CH_4

CH_4 recovered (combusted) = 46.199 * 0.6*0.5*0.6 = 9.69 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 = 2 610 000*18.25 = 47 643 Gg BOD/year

Formation of methane, on-site treatment = 47.643*0.09 = 4.29 Gg CH_4

Methane emissions (municipal wastewater) total = 9.14 + 10.52 – 9.69 + 4.29 = 14.26 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].

Tab. 9.6 Used methane conversion factors (MCF) and share of individual technologies [%] in 1990-2000

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

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 233.7 mil.m^3 [7], it was also possible to determine "unidentified" amount of wastewater (77.6 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], see Tab. 9.7.

Tab. 9.7 Calculation of COD generated by individual sub-sectors 2000

	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	69	11.00	24.00	0.10	1 831	16 482
Milk and diary production	911	2.70	7.00	0.10	1 721	15 492
Beer and malt	2 157	2.90	6.30	0.10	3 942	35 476
Meat and poultry	437	4.10	13.00	0.25	5 829	17 486
Organic chemicals	277	3.00	67.00	0.10	5 559	50 028
Petrochemical industry	7 000	1.00	0.60	0.10	420	3 780
Plastics and synthetic resin	919	3.70	0.60	0.10	204	1 837
Paper and wood pulp	524	9.00	162.00	0.25	191 095	573 286
Soap and detergents	53	0.85	3.00	0.10	13	121
Starch production	57	10.00	9.00	0.10	509	4 583
Sugar refining	367	3.20	9.00	0.10	1 057	9 510
Textiles (natural)	72	0.90	172.00	0.10	1 116	10 048
Vegetable oils	105	0.85	3.10	0.10	28	249
Fruit, vegetables and juices	130	5.00	20.00	0.25	3 244	9 731
Vine and vinegar	54	1.50	23.00	0.10	186	1 671
Unidentified wastewater	77 638	3.00	1.00	0.10	23 291	209 621

Total					**240 045**	**959 399**

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
Non-treated	0.05	29 %	18 %	13 %	12 %
Aerobic treatment of water	0.06	67 %	73 %	70 %	66 %
Anaerobic treatment of water	0.70	4 %	8 %	17 %	22 %
Aerobic treatment of water	0.10	40 %	40 %	40 %	40 %
Anaerobic treatment of water	0.30	60 %	60 %	60 %	60 %

Emissions from industrial wastewater for 2000:
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 = 0.71*0.06*0.25 + 0.24*0.70*0.25 + 0.06*0.05*0.25 = 0.0525kg CH_4/kg COD
Water COD = 959 Gg COD (see Tab. 9.7)
Sludge EF = sludge EF (aerobic) + sludge EF (anaerobic)
Sludge EF = 0.6*0.3*0.25 + 0.4*0.1*0.25 = 0.0550 kg CH_4/kg COD
Sludge COD= 240 Gg COD (see Tab. 9.7)
Oxidized methane = 0.24* 0.70 * 0.25 * 959 + 0.6 * 0.3 * 0.25 * 240 = 50.29 Gg (it's whole methane, which was formed from anaerobic processes)
Methane emissions from industrial wastewater handling = 959 * 0.0525 + 240 * 0.0550 – 50.29 = 13.26 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

$$N_2O \text{ emissions} = 10\,283\,000 * 25 * 0.16 * 0.01 * 44/28 / 1\,000\,000 = 0.647 \text{ Gg p.a.}$$

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 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].

9.3.2 Changes in inventories

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. 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 sector. Tables 9.4 and 9.9 give the recalculated time series.

Tab. 9.9 CH_4 emissions from municipal and industrial wastewater in 1990-2000 [Gg]

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Municipal wastewater											
CH_4 production	22.34	22.19	22.24	22.82	22.84	22.85	23.37	23.36	23.42	23.97	23.95
Oxidized CH_4	7.47	7.40	7.45	8.15	8.18	8.19	8.88	8.89	8.99	9.70	9.69
Total CH_4 emissions	14.86	14.79	14.79	14.67	14.67	14.66	14.49	14.47	14.43	14.27	14.26
Industrial wastewater											
CH_4 production	49.76	45.93	41.54	43.88	46.67	43.27	55.81	58.42	63.33	60.10	63.51
Oxidized CH_4	25.31	22.84	21.37	26.91	28.86	26.76	41.28	43.25	47.00	46.90	50.29
Total CH_4 emissions	24.45	23.09	20.17	16.97	17.81	16.50	14.53	15.16	16.34	13.17	13.26

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].

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10. Emissions of HFCs, PFCs and SF_6

This chapter is concerned with emissions of industrial fluorinated substances that are not covered by the *Montreal Protocol* and that affect climate change. These are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). These substances are monitored in the framework of the *UN Framework Convention on Climate Change* and the *Kyoto Protocol*. They are not produced in CR and requirements are met by imports. They are used in a number of branches of industry.

The main means of using HFCs is as a cooling medium. In this area, prohibited chlorofluorocarbons (CFCs) have been completely replaced and the use of partially halogenated chlorofluorohydrocarbons (HCFCs) has been reduced. They continue to be used to a limited degree as expanding agents in the production of foamed insulating materials, as propellants for aerosol (mostly pharmaceutical) preparations, as cleaning agents (especially for electrotechnology) and as fire extinguishers, replacing prohibitted 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 insulation between window panes.

The *IPCC Guidelines* [2] defines both the potential emissions for the inventory according to Tier 1 and the actual emissions for inventory according to Tier 2. Inventories in the Czech Republic are carried out using the method of potential emissions supplemented by information on use in the individual branches. Detailed emission inventories cannot be prepared on the basis of the current legislation - see below. 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 the given year. The method assumes that actual emissions should not exceed potential emissions.

As these substances are not produced in CR, information from the customs authorities on imports and exports are of key importance. These substances 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 nonmetal 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 necessary 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. In contrast to 1997 - 1999, the General Directorate of Customs provided information on imports and exports in 2000. Thus, it was possible to submit questions to importers on transported gas (or mixtures of gases) and the amounts thereof. The imported amounts and the manner of use can be calculated from their answers. In addition to verification of the above data, administrative errors that could occur for incorrect assignment of customs codes to the substances are excluded in this approach. The inventory was carried out in a similar manner in 1995 and 1996. In 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 was carried out analogous to 1996. For 1999 the calculation was also carried out using questionnaires sent to the assumed importers and users. Tables 10.1 and 10.2 give the results of these studies. The total potential emissions of industrial fluorinated substances according to information from importers in CR in 2000 equalled 889.6 Gg CO_2 equiv., of which emissions of HFCs formed 76%, emissions of SF_6 23% and emissions of PFCs 1%.

In 2001, recalculation was carried out for emissions of SF_6, HFCs and PFCs [4]. Several causes were found for the differences between the current and former values. Small differences are caused by rounding off in calculations. In one case, a typing error was involved and subsequently all calculations and input data were controlled. In other cases, the input data were refined on the basis of questionnaires submitted to the importers of the monitored substances.

Tab. 10.1 HFCs, PFCs and SF_6 potential emissions in 1995 – 2000 [kt CO_2 eq.]

	1995	1996	1997	1998	1999	2000
HFCs	2.2	134.1	295.6	381.8	411.9	674.3
PFCs	0.4	4.2	7.0	9.1	2.7	9.42
SF_6	166.8	183.1	323.1	131.7	110.9	205.9
Total	169.4	321.4	625.7	522.6	525.5	889.8

Tab. 10.2 HFCs, PFCs and SF_6 potential emissions from individual subsectors in 1995-2000 [kt CO_2 eq.]

	1995	1996	1997	1998	1999	2000
Electrical equipment	166.8	154.4	272.4	111.8	49.9	103.6
Window isolation	0	28.7	50.7	19.8	16.7	58.5
Semiconductor manufacture	0	0	0	0	45.1	46.5
Fire extinguishers	0.4	1.3	-	-	3.4	3.27
Foam blowing and aerosols	0.1	57	138.6	38.2	7.0	25.8
Refrigeration	2.1	80.4	164.0	352.1	403.4	652.2

Compared to the inventory of 1996, when the data was obtained in the same manner, in 2000 the consumption of HFCs increased five-fold, that of PFCs more than doubled while the values for SF_6 changed only negligibly in absolute figures. The consumption of PFCs is low compared with imports of the other F-gases. However, there was a significant change in the fractions of the individual groups in the total emissions of F-gases - see Table 10.3

Tab. 10.3 Structure of HFCs, PFCs and SF_6 potential emissions in 1995 – 2000 [%]

	1995	1996	1997	1998	1999	2000
HFCs	1.30	41.72	47.24	73.06	78.38	75.80
PFCs	0.24	1.31	1.13	1.74	0.51	1.06
SF_6	98.47	56.97	51.64	25.20	21.10	23.14

The increase in the consumption of HFCs (especially of the 134a type and, in refrigeration mixtures, also 143a and 125) is caused by their use as a replacement for prohibited CFCs and limited 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 emissions of greenhouse gases. Of substances of the HFC group, HFC-134a has the greatest importance and is used mainly in the refrigeration industry. Other types are employed in azeotropic refrigeration mixtures as additives, that are decisive for the thermodynamic properties of the refrigerant. The consumption of CFCs is increasing in CR. However, the absolute amounts are very small and are not expected to increase substantially in the future. They consist mainly of admixtures of PFCs in refrigeration mixtures and use in electrotechnology. The consumption of SF_6 varies over the years. The fields of use remain unchanged, with predominant use in electrotechnology and increased use for insulation between window panes. Table 10.4 gives the potential emissions of industrial fluorinated substances in 2000 as individual chemical substances.

In the overall evaluation of potential emissions of industrial fluorinated substances at the present time in CR, these substances correspond to only 0.62% of total emissions of greenhouse gases (See Tab. 11.2). The fraction of these emissions is increasing slowly and could exceed 1% in the future because of an increase in absolute emissions of these substances and also because of a decrease in total emissions of greenhouse gases.

Tab. 10.4 Potential emissions (consumption) in CR in 2000

	Potential emissions [t]	GWP_{100}	CO_2 eq. [Gg]
SF_6	8.62	23 900	**205.90**
CF_4	0.41	6 500	2.67
C_2F_6	0.03	9200	0.28
C_3F_8	0.93	7000	6.48
PFCs total			**9.42**
HFC-23	0.16	11 700	1.87
HFC-32	3.70	650	2.41
HFC-125	47.60	2 800	133.28
HFC-134a	255.66	1 300	332.36
HFC-143a	52.8	3 800	200.64
HFC-152a	3.50	140	0.49
HFC-236fa	0.52	6 300	3.28
HFCs total			**674.32**
F-gases total			**889.64**

References

1. Řeháček V., Michálek L.: *Information on emissions of greenhouse gases containing fluorine in CR in 2000.* Report for CHMI. (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. Conclusions

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 2000 is logically related to the inventory for 1999. It was prepared in accord with the *Good Practice Guidance*, i.e. for *key sources*; 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 the other cases, the standard recommended factors of the IPCC method were employed.

Tab. 11.1 gives the emissions of greenhouse gases with primary radiation absorption effect for the entire 1990 - 2000 period. The values given in the table were recalculated to the equivalent amount of carbon dioxide using the prescribed recalculation coefficients for the entire monitored period (1995 Global Warming Potential) and derived for a time period of 100 years, i.e. CO_2 = 1, CH_4 = 21, N_2O - 320. The values for fluorine-containing substances are given in units that are a thousand times smaller than for other gases. Further, it should be pointed out that the values for CO_2 already include sinks in forest management. More detailed results at the level of the IPCC Summary Tables are given in the Table Annex for the years 1990 and 1996 - 1999. In addition, the annex contains the much more detailed Sectoral Tables for the 2000, taken from the new CRF format and prescribed by the bodies of the *UN Framework Convention on Climate Change*. This *Common Reporting Format* also contains a number of other tables with supplementary information for control purposes.

Tab. 11.1 Overall results of GHG emissions inventories in 1990 and in 1996-2000

	1990	1996	1997	1998	1999	2000
CO_2 [mil. t] (emissions & removals)	161.9	128.3	132.7	124.5	117.7	123.9
CO_2 removals only [mil. t]	*-2.1*	*-4.5*	*-4.6*	*-3.8*	*-3.4*	*-4.0*
CH_4 [mil. t CO_2 eq.]	16.8	12.6	12.1	11.4	10.7	10.7
N_2O [mil. t CO_2 eq.]	11.3	9.2	8.8	8.4	8.1	8.2
HFCs, PFCs, SF_6 [thous. t CO_2 eq.]	169.4*	321.8	625.7	522.6	525.4	889.6
Total [mil. t CO_2 eq.]	189.9	150.4	154.2	144.8	137.0	143.7
% of 1990	100.0	79.2	81.2	76.3	72.2	75.7
Bunkers [mil. t CO_2 eq.]	0.6	0.5	0.4	0.2	0.5	0.3

* data for 1995

It is apparent from the table that the greatest decrease compared to the reference year of 1990 occurred at the beginning in 1990 and 1991 as a consequence of the decrease and then restructuring of production following the fundamental change in the political system (this change in the economy was not manifested yet in 1990). Since 1994, emissions have become stabilized, with an absolute minimum in 1999 (decrease by 27.8%). The reasons for the short-term increases and decreases in emissions in 1995 to 1999 are very difficult to evaluate. The temperature changes in the 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 formation of GDP could also have a non-negligible effect.

The fractions of the effects of the individual greenhouse gases in the monitored period are visible from Table 11.2. It is apparent that the values of the fractions change only insignificantly and within the framework of the precision of the inventories. In relation to the structure of the energy sector and industrial production in CR, the predominant gas is carbon dioxide, whose fraction is above the overall average for the countries of the European Union, while the fraction of methane, on the other hand, is below this average. The fraction of fluorine-containing substances currently equals 0.6% of total aggregated emissions. The expected increase in these substances as a consequence of replacement of prohibited substances depleting the ozone layer of the Earth cannot currently be fully demonstrated because of the currently inadequate customs regulations that prevent reliable records of imports of the individual substances.

Tab. 11.2 Relative contributions of single GHGs on the overall aggregated emissions in 1990 and in 1996-2000 [%]

	1990	1996	1997	1998	1999	2000
CO_2 [%]	85.2	85.3	86.0	86.0	85.9	86.2
CH_4 [%]	8.8	8.4	7.8	7.9	7.8	7.5
N_2O [%]	5.9	6.1	5.7	5.8	5.9	5.7
HFCs, PFCs, SF_6 [%]	-	0.2	0.4	0.4	0.4	0.6

The precision of determination of the emissions of the individual gases remains at the same level as last year, equal to the following ranges - carbon dioxide 7-10%, methane 35-40%, nitrous oxide 70-100%. The precision of the overall emission inventory can be estimated at 15%. These values are in acceptable agreement with the values given in foreign inventory reports. The current method of estimating the uncertainty, based primarily on expert estimates, is not fully satisfactory from the standpoint of the *Good Practice Guidance*. Thus, it will be necessary to devote greater attention to this aspect in the future and to employ at least Tier 1 according to the valid methodology to the required extent.

Abbreviations

APL	*Asociace průmyslových lihovarů*
	Association of Industrial Distilleries
AVNH	*Asociace výrobců nátěrových hmot*
	Association of Coatings Producers
ČHMÚ	*Český hydrometeorologický ústav*
ČHMI	*Czech Hydrometeorological Institute*
ČSÚ	*Český statistický úřad*
CSO	*Czech Statistical Office*
CDV	*Centrum dopravního výzkumu*
	Transport Research Centre
EEA	*European Environmental Agency*
IGU	*International Gas Union*
MŽP (ČR)	*Ministerstvo životního prostředí (ČR)*
MoE (CR)	*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

YEAR 2000

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

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
				(Gg)			
Total Energy	**124 959.78**	**287.18**	**4.78**	**368.41**	**516.01**	**120.96**	**243.35**
A. Fuel Combustion Activities (Sectoral Approach)	**124 420.10**	**19.41**	**4.78**	**368.06**	**515.49**	**119.67**	**238.16**
1. Energy Industries	**60 160.18**	**1.27**	**2.16**	**67.94**	**5.49**	**2.90**	**90.59**
a. Public Electricity and Heat Production	57 123.19	1.15	2.13	64.32	5.09	2.80	79.23
b. Petroleum Refining	1 198.17	0.06	0.00	1.55	0.24	0.03	7.49
c. Manufacture of Solid Fuels and Other Energy Industries	1 838.83	0.06	0.03	2.07	0.16	0.07	3.87
2. Manufacturing Industries and Construction	**36 130.13**	**1.16**	**0.65**	**45.91**	**6.07**	**1.22**	**81.94**
a. Iron and Steel	0.00	0.00	0.00				
b. Non-Ferrous Metals	0.00	0.00	0.00				
c. Chemicals	0.00	0.00	0.00				
d. Pulp, Paper and Print	0.00	0.00	0.00				
e. Food Processing, Beverages and Tobacco	0.00	0.00	0.00				
f. Other *(please specify)*	36 130.13	1.16	0.65	45.91	6.07	1.22	81.94
Only total of a-e available, treated as f				45.91	6.07	1.22	81.94
3. Transport	**11 110.49**	**1.92**	**1.66**	**197.92**	**291.08**	**77.69**	**5.51**
a. Civil Aviation	95.49	0.00	0.00	0.74	2.21	0.71	0.04
b. Road Transportation	10 344.24	1.90	1.64	189.23	284.32	74.95	5.28
c. Railways	285.97	0.02	0.01	6.63	3.90	1.83	0.17
d. Navigation	29.33	0.00	0.00	0.68	0.40	0.19	0.02
e. Other Transportation *(please specify)*	355.46	0.00	0.00	0.64	0.25	0.01	0.01
Gas pipelines transportation				0.64	0.25	0.01	0.01

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

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
				(Gg)			
4. Other Sectors	**15 873.66**	**14.82**	**0.26**	**19.96**	**174.00**	**28.11**	**58.21**
a. Commercial/Institutional	5 511.46	2.01	0.06	5.53	12.40	3.96	8.34
b. Residential	9 830.99	12.17	0.20	13.63	157.54	22.87	48.09
c. Agriculture/Forestry/Fisheries	531.21	0.64	0.01	0.80	4.06	1.28	1.78
5. Other ***(please specify)***[1]	**1 145.62**	**0.24**	**0.05**	**36.33**	**38.85**	**9.75**	**1.90**
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	1 145.62	0.24	0.05	36.33	38.85	9.75	1.90
Mobile sources from the Agriculture/Forestry/Fishing Sector are treated here.	1 145.62	0.24	0.05	36.33	38.85	9.75	1.90
B. Fugitive Emissions from Fuels	**539.69**	**267.77**	**0.00**	**0.34**	**0.52**	**1.29**	**5.20**
1. Solid Fuels	**539.69**	**239.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
a. Coal Mining	0.00	239.00	NE	NE	NE	NE	
b. Solid Fuel Transformation	IE	IE	IE	IE	IE	IE	IE
c. Other *(please specify)*	539.69	0.00	0.00	0.00	0.00	0.00	0.00
2. Oil and Natural Gas	**0.00**	**28.77**	**0.00**	**0.34**	**0.52**	**1.29**	**5.20**
a. Oil	0.00	0.37		0.34	0.52	1.29	5.20
b. Natural Gas	0.00	28.40				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	**343.02**	**0.10**	**0.01**	**2.08**	**6.30**	**2.44**	**0.24**
Aviation	343.02	0.10	0.01	2.08	6.30	2.44	0.24
Marine	0.00	0.00	0.00	NO	NO	NO	NO
Multilateral Operations	0.00	0.00	0.00				
CO_2 Emissions from Biomass	**2 362.01**						

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(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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	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 Industrial Processes	**2 250.74**	**3.40**	**3.63**	**674.32**	**0.00**	**9.42**	**0.00**	**205.90**	**0.00**	**27.24**	**126.98**	**10.70**	**21.09**
A. Mineral Products	**2 250.74**	**0.01**	**0.00**							**8.85**	**4.03**	**2.03**	**3.61**
1. Cement Production	2 040.27												0.94
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									0.16	1.91	0.01	0.20
7. Other *(please specify)*	210.47	0.01	0.00							8.69	2.12	2.01	2.47
Glass production										8.69	2.12	2.01	2.47
B. Chemical Industry	**0.00**	**0.39**	**3.63**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**8.24**	**2.91**	**0.00**	**4.38**
1. Ammonia Production	IE	0.00								3.96	2.90	0.00	NE
2. Nitric Acid Production			3.36							0.20			
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	4.08	0.01	0.00	4.38
Sum of other nonspecified items										4.08	0.01	0.00	4.38
C. Metal Production	**0.00**	**3.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**9.72**	**119.70**	**3.39**	**12.77**
1. Iron and Steel Production	0.00	2.56								8.77	116.71	2.95	11.73
2. Ferroalloys Production	0.00	0.00								0.00	0.00	0.06	0.04
3. Aluminium Production	0.00	0.00					0.00			NO	NO	NO	NO
4. SF_6 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	0.95	2.99	0.37	1.00
Sum of other nonspecified items										0.95	2.99	0.37	1.00

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

[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.

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

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	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)			
D. Other Production	**0.00**									**0.43**	**0.33**	**5.28**	**0.33**
1. Pulp and Paper										0.43	0.33	0.40	0.33
2. Food and Drink[2]	0.00											4.88	
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				**674.32**	**0.00**	**9.42**	**0.00**	**205.90**	**0.00**				
1. Refrigeration and Air Conditioning Equipment				645.26	0.00	6.76	0.00		0.00				
2. Foam Blowing				6.15	0.00		0.00		0.00				
3. Fire Extinguishers				3.27	0.00		0.00		0.00				
4. Aerosols/ Metered Dose Inhalers				19.64	0.00		0.00		0.00				
5. Solvents					0.00		0.00		0.00				
6. Semiconductor Manufacture					0.00	2.66	0.00	46.50	0.00				
7. Electrical Equipment								100.90	0.00				
8. Other *(please specify)*				0.00	0.00	0.00	0.00	58.50	0.00				
Other - nonspecified								58.50					
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**

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[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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	N_2O	NMVOC
		(Gg)	
Total Solvent and Other Product Use	**334.74**	**0.69**	**112.65**
A. Paint Application	**127.70**		**40.63**
B. Degreasing and Dry Cleaning	**135.11**		**42.99**
C. Chemical Products, Manufacture and Processing			**6.14**
D. Other *(please specify)*	71.92	0.69	22.89
(Use of N_2O for Anaesthesia)		0.35	
(N_2O from Fire Extinguishers)			
(N_2O from Aerosol Cans)		0.35	
(Other Use of N_2O)			
Other solvent use (SNAP 0604)	71.92		22.89

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_2O 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)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
			(Gg)		
Total Agriculture	**113.76**	**16.62**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation	**81.01**				
1. Cattle	64.59				
Dairy Cattle	41.94				
Non-Dairy Cattle	22.64				
2. Buffalo					
3. Sheep	0.42				
4. Goats	0.14				
5. Camels and Llamas					
6. Horses	1.13				
7. Mules and Asses					
8. Swine	12.58				
9. Poultry	2.16				
10. Other *(please specify)*	0.00				
B. Manure Management	**32.75**	**1.36**			**0.00**
1. Cattle	2.99				
Dairy Cattle	2.02				
Non-Dairy Cattle	0.97				
2. Buffalo					
3. Sheep	0.02				
4. Goats	0.01				
5. Camels and Llamas					
6. Horses	0.09				
7. Mules and Asses					
8. Swine	29.03				
9. Poultry	0.62				

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

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
			(Gg)		
B. Manure Management (continued)					
10. Anaerobic Lagoons		0.00			
11. Liquid Systems		0.20			
12. Solid Storage and Dry Lot		0.99			
13. Other *(please specify)*		0.18			0.00
		0.18			
C. Rice Cultivation	0.00				**0.00**
1. Irrigated	0.00				
2. Rainfed	0.00				
3. Deep Water	0.00				
4. Other *(please specify)*	0.00				0.00
D. Agricultural Soils (1)	**0.00**	**15.26**			**0.00**
1. Direct Soil Emissions		8.31			
2. Animal Production		0.95			
3. Indirect Emissions		6.01			
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			
2. Pulse	0.00	0.00			
3 . Tuber and Root	0.00	0.00			
4 . Sugar Cane	0.00	0.00			
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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	NO_x	CO
	(Gg)						
Total Land-Use Change and Forestry	**16 441.71**	**-20 457.90**	**-4 016.19**	**2.36**	**0.00**	**0.04**	**20.69**
A. Changes in Forest and Other Woody Biomass Stocks	**16 441.71**	**-20 457.90**	**-4 016.19**				
1. Tropical Forests			0.00				
2. Temperate Forests	16 441.71	-20 457.90	-4 016.19				
3. Boreal Forests			0.00				
4. Grasslands/Tundra			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							
2. Temperate Forests							
3. Boreal Forests							
4. Grasslands/Tundra							
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			0.00				
2. Temperate Forests			0.00				
3. Boreal Forests			0.00				
4. Grasslands/Tundra			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			0.00				
Cultivation of Organic Soils			0.00				
Liming of Agricultural Soils			0.00				
Forest Soils			0.00				
Other *(please specify)*[(3)]	0.00	0.00	0.00				
			0.00				
E. Other *(please specify)*	**0.00**	**0.00**	**0.00**	**2.36**	**0.00**	**0.04**	**20.69**
On-side burning of Cleared Forest			0.00	2.36	0.00	0.04	20.69

(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.

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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
				(Gg)			
Total Waste	**357.00**	**103.51**	**0.65**	**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	**0.00**	**75.98**		**0.00**	**0.00**	**0.00**	
1. Managed Waste Disposal on Land	0.00	75.98					
2. Unmanaged Waste Disposal Sites	0.00	0.00					
3. Other *(please specify)*	0.00	0.00		0.00	0.00	0.00	
B. Wastewater Handling		**27.52**	**0.65**	**0.00**	**0.00**	**0.00**	
1. Industrial Wastewater		13.26	0.00				
2. Domestic and Commercial Wastewater		9.97	0.65				
3. Other *(please specify)*		4.29	0.00	0.00	0.00	0.00	
C. Waste Incineration	**357.00**	**0.00**	**0.00**				
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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2	CO_2	CH_4	N_2O	HFCs(1)		PFCs(1)		SF_6		NO_x	CO	NMVOC	SO_2
		emissions	removals			P	A	P	A	P	A				
		(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**127 902.27**	**-4 016.19**	**510.21**	**26.37**	**674.32**	**0.00**	**9.42**	**0.00**	**205.90**	**0.00**	**395.69**	**663.68**	**244.31**	**264.45**
1. Energy		**124 959.78**		**287.18**	**4.78**							**368.41**	**516.01**	**120.96**	**243.35**
A. Fuel Combustion	Reference Approach (2)	122 116.35													
	Sectoral Approach (2)	124 420.10		19.41	4.78							368.06	515.49	119.67	238.16
1. Energy Industries		60 160.18		1.27	2.16							67.94	5.49	2.90	90.59
2. Manufacturing Industries and Construction		36 130.13		1.16	0.65							45.91	6.07	1.22	81.94
3. Transport		11 110.49		1.92	1.66							197.92	291.08	77.69	5.51
4. Other Sectors		15 873.66		14.82	0.26							19.96	174.00	28.11	58.21
5. Other		1 145.62		0.24	0.05							36.33	38.85	9.75	1.90
B. Fugitive Emissions from Fuels		539.69		267.77	0.00							0.34	0.52	1.29	5.20
1. Solid Fuels		539.69		239.00	0.00							0.00	0.00	0.00	0.00
2. Oil and Natural Gas		0.00		28.77	0.00							0.34	0.52	1.29	5.20
2. Industrial Processes		**2 250.74**		**3.40**	**3.63**	**674.32**	**0.00**	**9.42**	**0.00**	**205.90**	**0.00**	**27.24**	**126.98**	**10.70**	**21.09**
A. Mineral Products		2 250.74		0.01	0.00							8.85	4.03	2.03	3.61
B. Chemical Industry		0.00		0.39	3.63	0.00	0.00	0.00	0.00	0.00	0.00	8.24	2.91	0.00	4.38
C. Metal Production		0.00		3.00	0.00				0.00		0.00	9.72	119.70	3.39	12.77
D. Other Production (3)		0.00										0.43	0.33	5.28	0.33
E. Production of Halocarbons and SF_6							0.00		0.00		0.00				
F. Consumption of Halocarbons and SF_6						674.32	0.00	9.42	0.00	205.90	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 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. 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
2000
Submission 2002

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)			
3. Solvent and Other Product Use	**334.74**			**0.69**							**0.00**	**0.00**	**112.65**	0.00
4. Agriculture	**0.00**	**0.00**	**113.76**	**16.62**							0.00	0.00	0.00	0.00
A. Enteric Fermentation			81.01											
B. Manure Management			32.75	1.36									0.00	
C. Rice Cultivation			0.00										0.00	
D. Agricultural Soils	(4)	(4)	0.00	15.26									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) **-4 016.19**	**2.36**	**0.00**							**0.04**	**20.69**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	(5) 0.00	(5) -4 016.19												
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. CO_2 Emissions and Removals from Soil	(5) 0.00	(5) 0.00												
E. Other	(5) 0.00	(5) 0.00	2.36	0.00							0.04	20.69	NE	NE
6. Waste	**357.00**		**103.51**	**0.65**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	(6) 0.00		75.98									0.00	0.00	
B. Wastewater Handling			27.52	0.65							0.00	0.00	0.00	
C. Waste Incineration	(6) 357.00		0.00	0.00							0.00	0.00	0.00	0.00
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), CO_2 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 CO_2 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 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 (+).

(6) Note that CO_2 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
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items: [7]														
International Bunkers	**343.02**		**0.10**	**0.01**							**2.08**	**6.30**	**2.44**	**0.24**
Aviation	343.02		0.10	0.01							2.08	6.30	2.44	0.24
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	**2 362.01**													

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[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
2000
Submission 2002

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		127 902.27	-4 016.19	510.21	26.37	674.32	0.00	9.42	0.00	205.90	0.00	395.69	663.68	244.31	264.45
1. Energy		124 959.78		287.18	4.78							368.41	516.01	120.96	243,35
A. Fuel Combustion	Reference Approach(2)	122 116.35													
	Sectoral Approach(2)	124 420.10		19.41	4.78							368.06	515.49	119.67	238,16
B. Fugitive Emissions from Fuels		539.69		267.77	0.00							0.34	0.52	1.29	5.20
2. Industrial Processes		2 250.74		3.40	3.63	674.32	0.00	9.42	0.00	205.90	0.00	27.24	126.98	10.70	21,09
3. Solvent and Other Product Use		334.74			0.69							0.00	0.00	112.65	0.00
4. Agriculture (3)		0.00	0.00	113.76	16.62							0.00	0.00	0.00	0,00
5. Land-Use Change and Forestry		(4) 0.00	(4) -4 016.19	2.36	0.00							0.04	20.69	0.00	0.00
6. Waste		357.00		103.51	0.65							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		343.02		0.10	0.01							2.08	6.30	2.44	0,24
Aviation		343.02		0.10	0.01							2.08	6.30	2.44	0,24
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		2 362.01													

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 (+).

Appendix II

BASIC SURVEY OF THE EMISSION INVENTORIES FOR THE YEARS 1990 AND 1996 – 1999*

* HFCs, PFCs, SF_6 data for 1995 - 1999

TABLE 10 EMISSIONS TRENDS (CO_2)
(Sheet 1 of 5)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)										
1. Energy		**160 080**						**129 592**	**134 166**	**124 903**	**118 038**
A. Fuel Combustion (Sectoral Approach)		160 080						129 516	133 925	124 486	117 501
1. Energy Industries		59 171						57 818	59 180	58 706	53 848
2. Manufacturing Industries and Construction		59 457						43 867	43 341	35 376	34 156
3. Transport		7 275						9 896	11 392	10 779	12 016
4. Other Sectors		34 177						17 936	20 013	19 624	17 481
5. Other											
B. Fugitive Emissions from Fuels		0						76	241	417	537
1. Solid Fuels								76	241	417	537
2. Oil and Natural Gas											
2. Industrial Processes		**3 380**						**2 479**	**2 498**	**2 661**	**2 362**
A. Mineral Products		3 380						2 479	2 498	2 661	2 362
B. Chemical Industry											
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		**530**						**352**	**336**	**347**	**336**
4. Agriculture		**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**						**-4 486**	**-4 639**	**-3 757**	**-3 401**
A. Changes in Forest and Other Woody Biomass Stocks		-2 128						-4 486	-4 639	-3 757	-3 401
B. Forest and Grassland Conversion											
C. Abandonment of Managed Lands											
D. CO_2 Emissions and Removals from Soil											
E. Other											
6. Waste		**0**						**357**	**357**	**357**	**357**
A. Solid Waste Disposal on Land											
B. Waste-water Handling											
C. Waste Incineration								357	357	357	357
D. Other											
7. Other *(please specify)*		**0**						**0**	**0**	**0**	**0**
Total Emissions/Removals with LUCF [4]		**161 862**						**128 294**	**132 718**	**124 511**	**117 692**
Total Emissions without LUCF[4]		**163 990**						**132 780**	**137 357**	**128 268**	**121 093**
Memo Items:											
International Bunkers		**617**						**459**	**407**	**225**	**539**
Aviation		617						459	407	225	539
Marine											
Multilateral Operations											
CO_2 Emissions from Biomass											

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(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 CO_2 emissions and removals from Land-Use Change and Forestry.

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)										
Total Emissions		**798.26**						**599.72**	**575.50**	**543.83**	**509.10**
1. Energy		**453.38**						**334.63**	**329.72**	**303.75**	**278.68**
A. Fuel Combustion (Sectoral Approach)		59.31						33.95	31.27	22.51	20.95
1. Energy Industries		7.10						2.57	2.26	2.24	1.66
2. Manufacturing Industries and Construction		1.23						1.03	1.51	1.21	1.28
3. Transport		3.07						3.51	4.29	1.86	1.90
4. Other Sectors		47.91						26.83	23.22	17.19	16.12
5. Other											
B. Fugitive Emissions from Fuels		394.07						300.68	298.45	281.23	257.73
1. Solid Fuels		361.90						268.42	263.47	253.05	228.96
2. Oil and Natural Gas		32.17						32.26	34.98	28.18	28.77
2. Industrial Processes		**5.60**						**4.90**	**3.91**	**4.02**	**3.92**
A. Mineral Products								0.16	0.01	0.00	0.00
B. Chemical Industry		0.40						0.39	0.39	0.39	0.40
C. Metal Production		5.20						4.34	3.51	3.63	3.52
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											
4. Agriculture		**204.19**						**133.83**	**129.11**	**121.13**	**120.50**
A. Enteric Fermentation		155.78						97.83	92.86	85.83	85.16
B. Manure Management		48.41						35.99	36.25	35.30	35.34
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**						**2.31**	**2.25**	**2.25**	**2.58**
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		2.58						2.31	2.25	2.25	2.58
6. Waste		**132.51**						**124.06**	**110.51**	**112.70**	**103.42**
A. Solid Waste Disposal on Land		93.20						95.04	80.87	81.93	75.98
B. Waste-water Handling		39.31						29.02	29.64	30.77	27.43
C. Waste Incineration											
D. Other											
7. Other *(please specify)*		**0.00**						**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International Bunkers		**0.18**						**0.16**	**0.12**	**0.07**	**0.16**
Aviation		0.18						0.16	0.12	0.07	0.16
Marine											
Multilateral Operations											
CO_2 Emissions from Biomass											

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)										
Total Emissions		**36.34**						**29.71**	**28.42**	**27.07**	**26.17**
1. Energy		**4.57**						**4.16**	**4.31**	**4.47**	**4.46**
A. Fuel Combustion (Sectoral Approach)		4.57						4.16	4.31	4.47	4.46
1. Energy Industries		2.08						1.34	1.29	2.06	1.95
2. Manufacturing Industries and Construction		1.27						0.44	0.43	0.63	0.60
3. Transport		0.26						1.77	1.94	1.41	1.58
4. Other Sectors		0.96						0.61	0.65	0.38	0.33
5. Other											
B. Fugitive Emissions from Fuels		0.00						0.00	0.00	0.00	0.00
1. Solid Fuels											
2. Oil and Natural Gas											
2. Industrial Processes		**3.90**						**3.33**	**3.60**	**3.86**	**3.22**
A. Mineral Products											
B. Chemical Industry		3.90						3.33	3.60	3.86	3.22
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**						**1.00**	**0.60**	**0.71**	**0.69**
4. Agriculture		**26.56**						**20.57**	**19.26**	**17.39**	**17.14**
A. Enteric Fermentation											
B. Manure Management		2.14						1.55	1.52	1.44	1.44
C. Rice Cultivation											
D. Agricultural Soils		24.41						19.02	17.73	15.95	15.70
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**
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
6. Waste		**0.65**						**0.65**	**0.65**	**0.65**	**0.65**
A. Solid Waste Disposal on Land											
B. Waste-water Handling		0.65						0.65	0.65	0.65	0.65
C. Waste Incineration											
D. Other											
7. Other *(please specify)*		**0.00**						**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International Bunkers		**0.02**						**0.00**	**0.00**	**0.01**	**0.01**
Aviation		0.02						0.00	0.00	0.01	0.01
Marine											
Multilateral Operations											
CO_2 Emissions from Biomass											

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)										
Emissions of HFCs[(5)] - CO_2 equivalent (Gg)							**2.21**	**134.51**	**295.62**	**381.78**	**411.87**
HFC-23							0.00	0.00	0.00	0.00	0.00
HFC-32							0.00	0.00	0.00	0.00	0.00
HFC-41							0.00	0.00	0.00	0.00	0.00
HFC-43-10mee							0.00	0.00	0.00	0.00	0.00
HFC-125							0.00	0.00	0.00	0.00	0.03
HFC-134							0.00	0.00	0.00	0.00	0.00
HFC-134a							0.00	0.10	0.23	0.29	0.14
HFC-152a							0.00	0.00	0.00	0.00	0.00
HFC-143							0.00	0.00	0.00	0.00	0.00
HFC-143a							0.00	0.00	0.00	0.00	0.03
HFC-227ea							0.00	0.00	0.00	0.00	0.00
HFC-236fa							0.00	0.00	0.00	0.00	0.00
HFC-245ca							0.00	0.00	0.00	0.00	0.00
Emissions of PFCs[(5)] - CO_2 equivalent (Gg)							**0.35**	**4.21**	**7.00**	**9.10**	**2.70**
CF_4							0.00	0.00	0.00	0.00	0.00
C_2F_6							0.00	0.00	0.00	0.00	0.00
C_3F_8							0.00	0.00	0.00	0.00	0.00
C_4F_{10}							0.00	0.00	0.00	0.00	0.00
$c\text{-}C_4F_8$							0.00	0.00	0.00	0.00	0.00
C_5F_{12}							0.00	0.00	0.00	0.00	0.00
C_6F_{14}							0.00	0.00	0.00	0.00	0.00
Emissions of SF_6[(5)] - CO_2 equivalent (Gg)							**166.82**	**183.07**	**323.13**	**131.69**	**110.85**
SF_6							0.01	0.01	0.01	0.01	0.00

Chemical	GWP
HFCs	
HFC-23	11700
HFC-32	650
HFC-41	150
HFC-43-10mee	1300
HFC-125	2800
HFC-134	1000
HFC-134a	1300
HFC-152a	140
HFC-143	300
HFC-143a	3800
HFC-227ea	2900
HFC-236fa	6300
HFC-245ca	560
PFCs	
CF_4	6500
C_2F_6	9200
C_3F_8	7000
C_4F_{10}	7000
$c\text{-}C_4F_8$	8700
C_5F_{12}	7500
C_6F_{14}	7400
SF_6	23900

[(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 CO_2 equivalent emissions in order to facilitate data flow among spreadsheets.

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Czech Republic
2000
Submission 2002

GREENHOUSE GAS EMISSIONS	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)										
Net CO_2 emissions/removals		161 862					0	128 294	132 718	124 511	117 692
CO_2 emissions (without LUCF) [6]		163 990					0	132 780	137 357	128 268	121 093
CH_4		16 763					0	12 594	12 085	11 421	10 691
N_2O		11 266					0	9 211	8 811	8 390	8 111
HFCs		0					2	135	296	382	412
PFCs		0					0	4	7	9	3
SF_6		0					167	183	323	132	111
Total (with net CO_2 emissions/removals)		**189 891**					**169**	**150 421**	**154 240**	**144 844**	**137 020**
Total (without CO_2 from LUCF) [6]		**192 019**					**169**	**154 907**	**158 879**	**148 602**	**140 421**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)										
1. Energy		171 018					0	137 909	142 428	132 666	125 274
2. Industrial Processes		4 708					169	3 936	4 323	4 465	3 968
3. Solvent and Other Product Use		734					0	662	522	566	551
4. Agriculture		12 521					0	9 188	8 681	7 933	7 844
5. Land-Use Change and Forestry [7]		-2 073					0	-4 437	-4 591	-3 710	-3 346
6. Waste		2 983					0	3 163	2 878	2 924	2 729
7. Other		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.