Ministry of Environment and Water
Climate Change and Energy Department

Hungarian Meteorological Service
Greenhouse Gas Inventory Division

National Inventory Report for 1985-2005

Hungary

June 2007

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EXECUTIVE SUMMARY

ES.1. Background information

Pursuant to the UN Framework Convention on Climate Change (UNFCCC), Hungary has been preparing annual inventories of greenhouse gas emissions using the IPCC methodology since 1994. Due to the drastic reduction of production in the energy sector, industry and agriculture in the beginning of the 1990's, the average of 1985, 1986 and 1987 was selected as base year. Base years are used as points of reference for the greenhouse gas reduction program, under which Hungary has undertaken to reduce the emissions by 6 %.

In the early years of inventory preparation, it was problematic to ensure time series consistency because of capacity shortage of the inventory team. Finally, a recalculation project was started in 2003 with the support of the Ministry of Environment and Water. Additionally, specific national emission factors were determined for a number of technologies thereby increasing the accuracy of the inventories. Eventually, a consistent time series including each of the years of 1985 through 2003 (19 years in total) was generated by early 2005. At the same time, the inventory compilers started using the recently issued CRF Reporter program. The details of the recalculations can be found in the previous national inventory reports (2003, 2004). As of the 1st of January 2006, the GHG emission inventories have been prepared under the coordination and with the participation of the Ministry of Environment and Water. Later in this year a Greenhouse Gas Inventory Division was established in the Hungarian Meteorological Service (OMSZ). While in the current inventory cycle the inventory preparation and compilation was a joint effort of the Ministry and the Service, in the future OMSZ will be responsible for all inventory related tasks.

The main purpose of this National Inventory Report is to describe the input data and calculation methodologies on which the emissions estimates are based thus increasing the transparency of the inventory. The present report refers to the inventory time series for the years 1985-2005. The NIR provides relevant background information on institutional arrangements, QA/QC procedures and other information underlying the inventory compilation in Chapter 1. In Chapter 2 the trends for aggregated greenhouse gas emissions are discussed. The following chapters provide detailed information on each of the main source categories. Chapter 10 discusses details of recalculations and planned improvements. In the Annexes key category analysis and complementary methodological information can be found.

ES.2. Summary of trends

An overview of the time series of emissions suggests that the national emission rates are significantly lower in comparison with the base year. More specifically, an abrupt drop occurred in the beginning of the period as a result of the significant reduction in the output of the national economy. Since the middle of the 1990's, annual emissions have been fluctuating around the level of 79,000 Gg.

GREENHOUSE GAS EMISSIONS (CO_{2eq}, Gg)	AY*	BY**	1990	1991	1992	1993	1994	1995	1996
CO_2 emissions without LULUCF	85,969	85,969	73,190	69,304	62,867	63,711	62,598	61,940	63,290
CH_4 emissions without LULUCF	10,139	10,139	9,455	9,282	8,581	8,304	8,147	8,217	8,313
N_2O emissions without LULUCF	19,224	19,224	15,152	10,951	9,116	8,925	9,821	8,821	9,540
HFCs	0.0	1.7	0.0	0.0	0.0	0.1	1.1	1.7	1.6
PFCs	268.5	166.8	270.8	233.7	134.8	145.7	158.9	166.8	159.4
SF_6	81.0	70.1	39.9	52.7	49.0	51.8	67.9	70.1	69.0
Total (including total CO_2eq from LULUCF)	**112,564**	**112,454**	**94,230**	**85,534**	**75,524**	**74,277**	**73,428**	**71,299**	**77,645**
Total (excluding total CO_2eq from LULUCF)	**115,682**	**115,571**	**98,108**	**89,823**	**80,747**	**81,137**	**80,794**	**79,217**	**81,373**

GREENHOUSE GAS EMISSIONS (CO_{2eq}, Gg)	1997	1998	1999	2000	2001	2002	2003	2004	2005
CO_2 emissions without LULUCF	61,553	60,790	60,708	58,931	60,343	58,762	61,912	60,267	61,808
CH_4 emissions without LULUCF	8,248	8,261	8,271	8,269	8,094	8,089	8,075	7,836	7,777
N_2O emissions without LULUCF	9,340	9,512	9,443	9,553	10,059	9,449	9,418	10,167	9,707
HFCs	45.2	125.1	347.3	205.7	280.7	403.6	498.9	525.8	517.6
PFCs	161.4	192.6	209.6	211.3	199.1	203.3	189.6	201.1	209.4
SF_6	68.0	68.5	126.8	140.1	107.4	119.6	161.9	178.2	201.0
Total (including total CO_2eq from LULUCF)	**75,707**	**73,715**	**77,312**	**75,441**	**75,599**	**73,926**	**75,480**	**74,735**	**75,743**
Total (excluding total CO_2eq from LULUCF)	**79,415**	**78,949**	**79,105**	**77,310**	**79,083**	**77,026**	**80,255**	**79,176**	**80,219**

Table ES. 1. **AY =average of 1985-87 and ** BY=average of 1985-87 but 1995 for F-gases*

As demonstrated by the figure below, emissions were reduced in the Energy, Agriculture, Industry and Solvent sectors. In contrast, the emissions in Waste sector are increasing. In the Land Use, Land-Use Change and Forestry (LULUCF) sector removals (negative value!) show fluctuating behaviour. The land use change exerts significant influence on the emission/removal of this sector, especially when calculated in accordance with the new methodology.

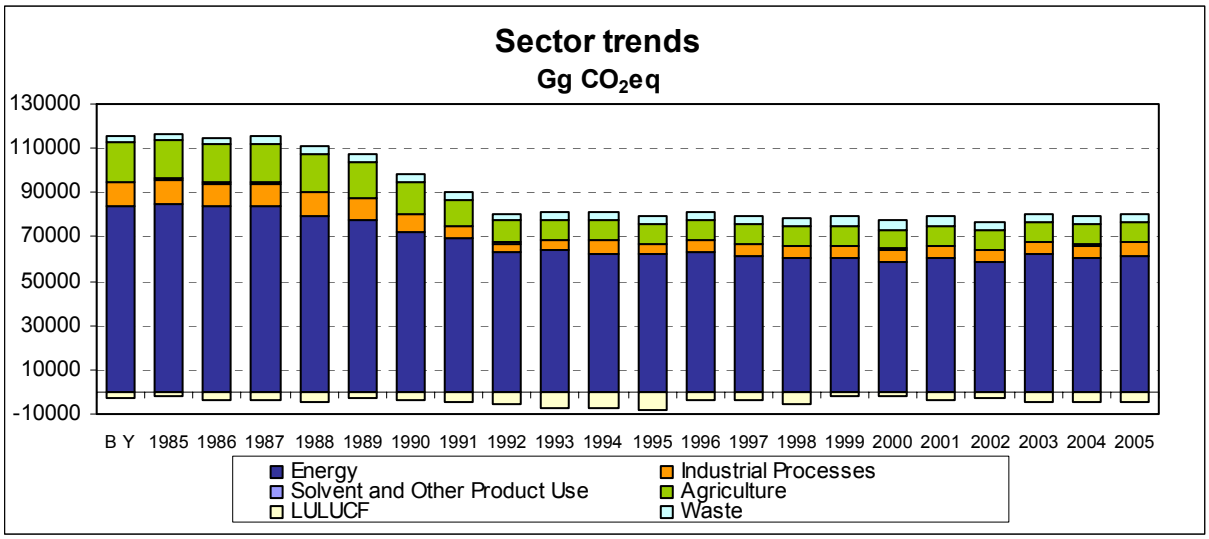

Figure ES. 1. *Change in greenhouse gas gmissions from base year (1985-2005)*

Note: BY=average of 1985-87 but 1995 for F-gases

As regards the trends of the emissions of different gases, CO_2, CH_4 and N_2O show decreasing tendencies. The reduction of CO_2 emission was particularly high earlier while showing a fluctuating tendency in recent years.

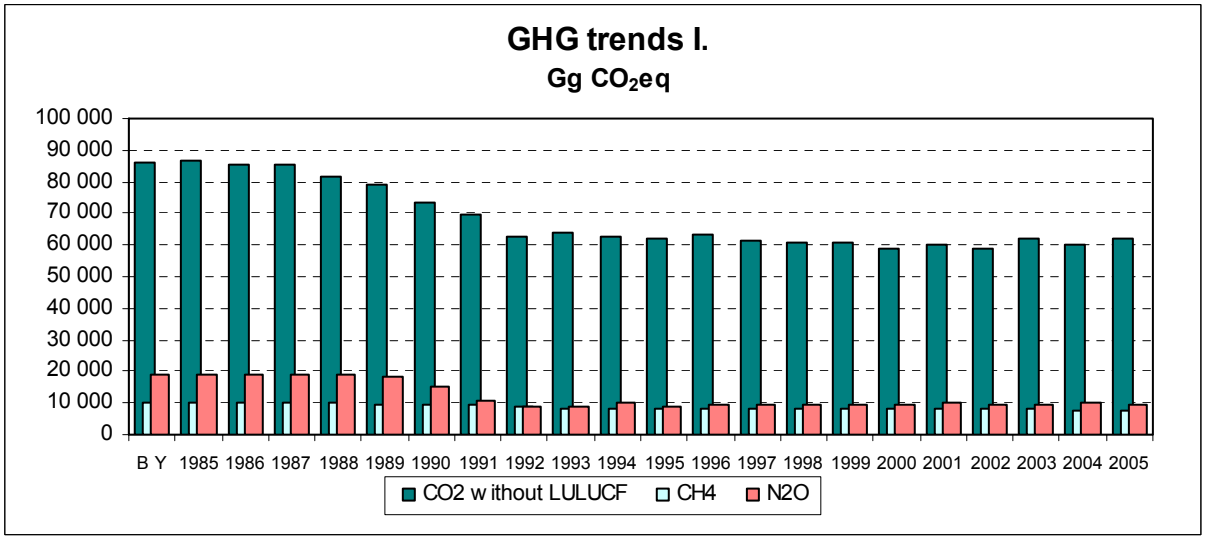

Figure ES 2. *Trend of emissions by gases*

Note: BY=average of 1985-87 but 1995 for F-gases

The overall trend for fluoride gases is an increasing one. Based on information from companies, the use of HFCs in the household refrigerators industry started in 1992, reached its maximum at the end of the 1990's, and since then it has been continuously decreasing. At the same time, total emissions show a continuous increase. (Figure ES 3.)

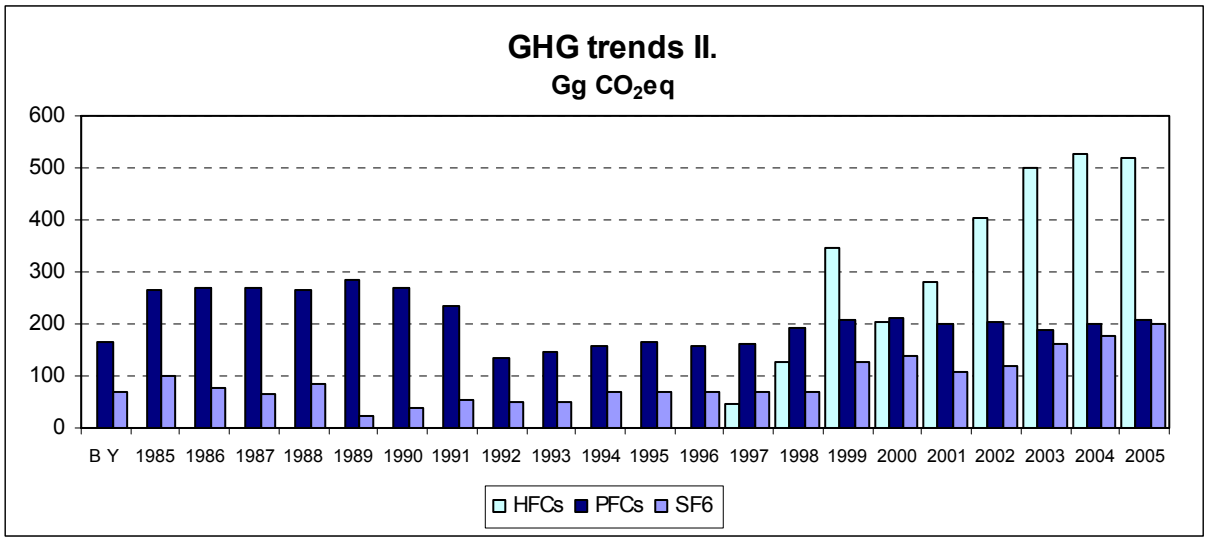

Figure ES 3. *F gases trend (1985-2005)*

*Note: *BY=average of 1985-87 but 1995 for F-gases*

The figure below shows the CO_2 removals by forests:

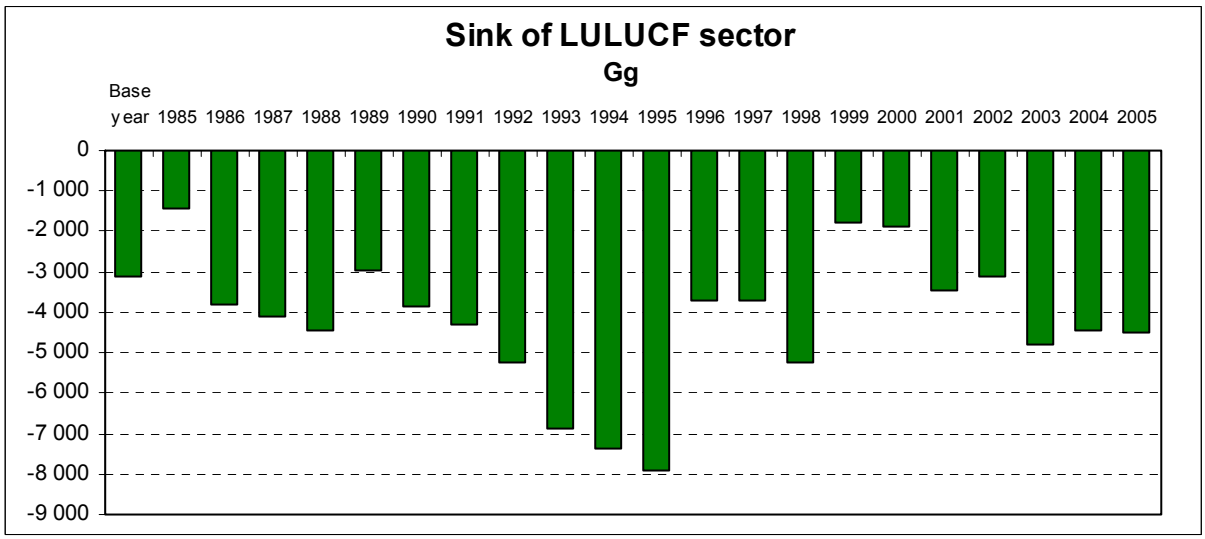

Figure ES 4. *Sink of LULUCF*

The actual values are significantly influenced by the changes in the CO_2 balance of the soil. The new calculations based on the LULUCF GPG brought changes to the trend to some extent.

ES.3. Indirect greenhouse and SO_2 gases

NO_X, CO and NMVOC gases are referred to as indirect gases because they influence (reduce or increase) atmospheric warming indirectly, via secondary effects. Calculation of the emissions of these gases was required by the IPCC 1996 Revised Guidelines and the CRF programme provided a certain level of information technology background. It should be noted that Hungary (as well as the other European countries) has calculated the emissions of such gases for several decades and the Geneva Convention of 1979 (CLRTAP) also laid down such obligations. Since 1999, the above-mentioned programme has also been used for calculating the emissions of indirect gases. No recalculations have been made for the preceding years because data from 1980 on are available from the National Emissions Database (NED). Thus, the trends of emissions are as follows (Gg):

Indirect gases	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
NO_X	*262.5*	*264.2*	*264.9*	*257.8*	*246.8*	*238*	*203.1*	*183.3*	*184*	*187.4*	*190.07*
CO	*931.1*	*--*	*--*	*963.1*	*--*	*997*	*913.4*	*835.8*	*796.1*	*774.29*	*761.29*
NMVOC	*232*	*263*	*228*	*215*	*205*	*205*	*149.6*	*141.8*	*149*	*142.4*	*150.3*
SO_2	*1403.6*	*1361.8*	*1285.3*	*1218*	*1102*	*1010*	*913*	*827.3*	*757.3*	*741*	*704.96*

Indirect gases	*1996*	*1997*	*1998*	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	
NO_X	*195.81*	*199.5*	*202.62*	197.4	185.1	183.2	183.0	210.7	185.3	203.1	
CO	*726.87*	*733.36*	*736.93*	592.4	592.4	578.8	573.8	600.3	585.4	585.2	
NMVOC	*150.1*	*145.4*	*140.6*	165.5	166.0	162.3	160.1	169.0	157.0	176.2	
SO_2	*673.23*	*658.51*	*591.79*	598.0	489.0	403.9	364.9	347.8	248.8	146.6	

***Table ES 2.** Emissions of indirect gases. The database is not complete for the 80's.*

The reduction in sulphur dioxide emissions is attributable to the decrease in the use and the reduced sulphur content of fossil fuels. After 2000, further reductions were observed due to the introduction of SO_2 precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously due to the reduced fuel uses. NO_X and NMVOC emissions show no significant trend in the last 15 years.

1. INTRODUCTION

1.1 Background information and climate change

Hungary submitted the First National Communication in 1994 when the country joined the UN Framework Convention on Climate Change (hereinafter referred to as the Convention). In conjunction with this, the greenhouse gas inventories of the preceding years were prepared. Since then, we have continued to prepare such inventories. According to the Convention, the year 1990 considered as general reference level was not adequate for us as a base year because the economic output of the country in this period was already on the descending course as a result of the ongoing transition to market economy. Therefore, it would have been highly unfavourable for us to take 1990 as base year. Finally, the average of years 1985, 1986 and 1987 (hereinafter referred to as ”base years”) was selected because these three years represented a certain level of stability in the fluctuating economic output. This request was accepted by the COP.

With the introduction of additional greenhouse gases, it was necessary to select the corresponding base years. (This is particularly important for HFCs because such gases have been increasingly used since the early 1990’s as a replacement for ozone depleting chlorofluorocarbons.) In our Initial Report submitted last year we have chosen the year 1995 as the base year for fluoride gases.

The process of inventory preparation has been improved year by year. We did our best to meet the changing and growing requirements but there were delays due to limited human resources. (See our NIR for the year 2004 for more details.) In addition to filling the annual databases as far as possible, we placed particular emphasis on determining the specific emission factors for Hungary.

The new CRF Reporter program was put to use in 2005, during the preparation of the 2003 inventory. In that year, entire time series of data were submitted in both the old CRF format and the new CRF Reporter. During the preparation of the inventory for the year 2004, also the emissions of the LULUCF sector were calculated according to the new method (GPG for LULUCF). However, we could not or could only partially do it for the preceding years due to the above-mentioned lack of capacity. In connection with the Initial Report, we prepared again all the inventories (1985-2004) reducing their incompleteness. We completed for example the calculations of the LULUCF sector according to the new requirements and supplied a few missing data for the base years, etc. The modified inventories were submitted in August 2006 to the UNFCCC Secretariat and the EU.

In early March 2007 the Expert Review Team of UNFCCC made a thorough in-depth in-country review. During this review a few potential problems were found. In collaboration

between the ERT and the Hungarian experts, these problems could be fixed. However, some recalculations were necessary which led to changes also in the emissions of the base year and consequently in the assigned amount. (See chapter 10 for more details).

The regional effects of the global climate change can be clearly seen on the Hungarian observations. The annual averages of temperature in Hungary are very similar to the well-known wave of the global temperature since the beginning of the 20th century. The warming is 0.77°C for the period 1901-2006. (The annual average of temperature is 9.96°C in Hungary for the standard normal period 1961-1990). The largest warming is observed in summer. The growing rate is approximately 1°C in this season for the period 1901-2005. The average temperature of summers is 19.61°C in 1961-1990. Hungary experienced many hot summers in the last 15 years. According to the Hungarian heat stress warning levels, if the daily mean exceeds 25°C at least on three consecutive days, the medical risk rises by 15%, and if the daily mean is above 27°C at least on three consecutive days, the rising of the risk is 30%. Increasing tendency was found in all extreme warm index series from 1901. The number of summer days grew by 6, the number of tropical nights by 7 on the national average. Similar increase is observed in the occurrence of hot periods with 25°C average temperature. The heat waves with 27ºC temperature grew also by 3 days in the analysed years.

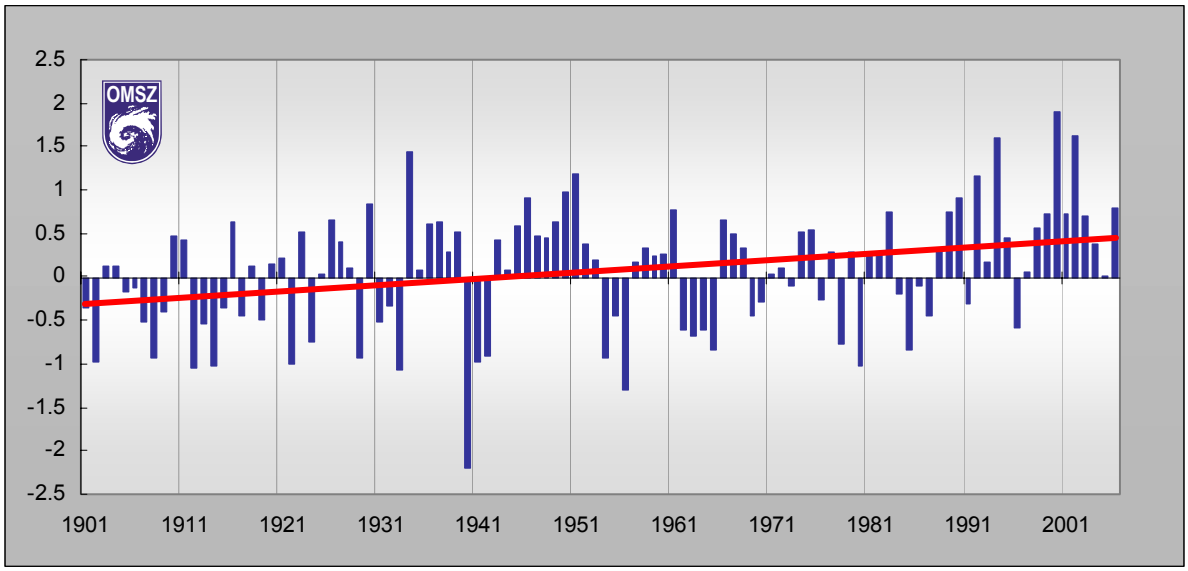

Figure 1.1. *Homogenized annual average temperature anomalies (°C) 1901-2006 relative to 1961-1990 in Hungary. The warming is 0,77°C by linear estimation for 106 years.*

Heating degree day (HDD) and cooling degree day (CDD) are quantitative indices demonstrated to reflect demand for energy to heat or cool houses and businesses. These indices are derived from daily temperature observations. The degree days were calculated over a year by adding up the differences between each day's mean daily temperature and

the balance point temperature of 18°C. If the daily mean temperature is greater than 18°C, then we have (average temperature - 18) cooling degree days. If the average temperature is less than 18 degrees, then we have (18 - average temperature) heating degree days. The following figures show the time series of these indices. It can be seen that especially the cooling degree day values can show significant changes year by year.

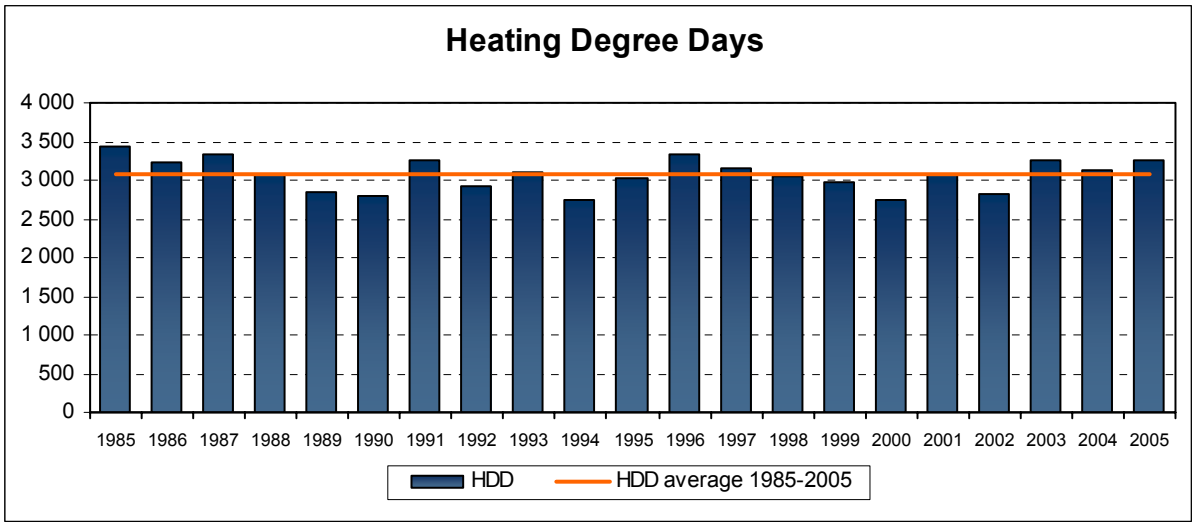

Figure 1.2. *Heating degree day values in Hungary for the period 1985-2005*

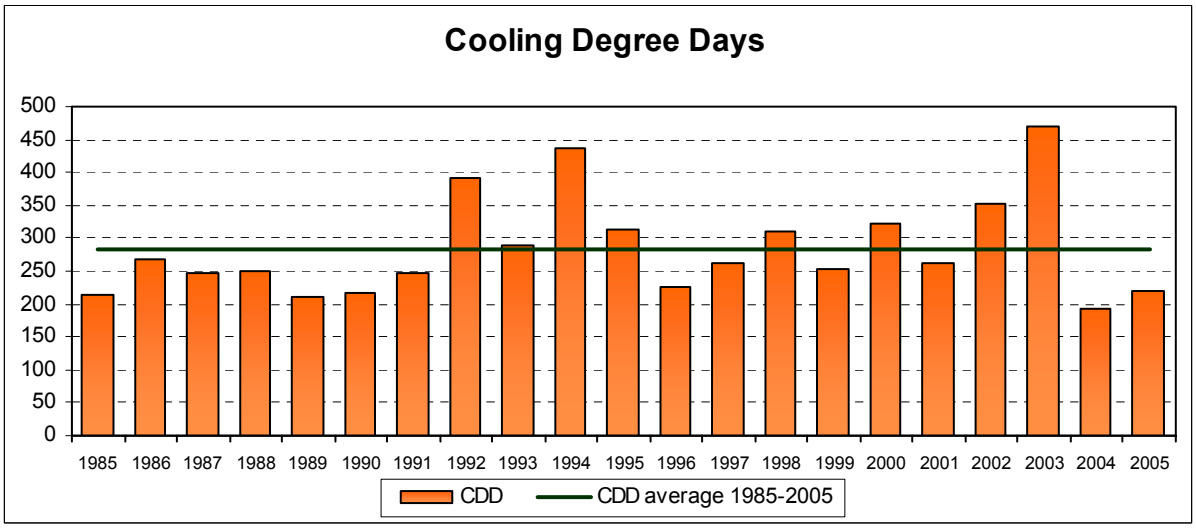

Figure 1.3. *Cooling degree day values in Hungary for the period 1985-2005*

The year **2005** was countrywide a *bit colder* than the average of many years. However, during the year there were also temperature extremities. For example, the first half of January was by 6-8 ºC warmer, while February much colder than the average. In the end of May the warm records of the century fell at several points of the country, and then, barely two weeks later, the weather was so extraordinarily cold that, those who could do so, turned on again the heating. In 2005 the countrywide yearly mean temperature was 9.7 ºC which

was by 0.2 ºC less than the 30-year average between 1961-90.

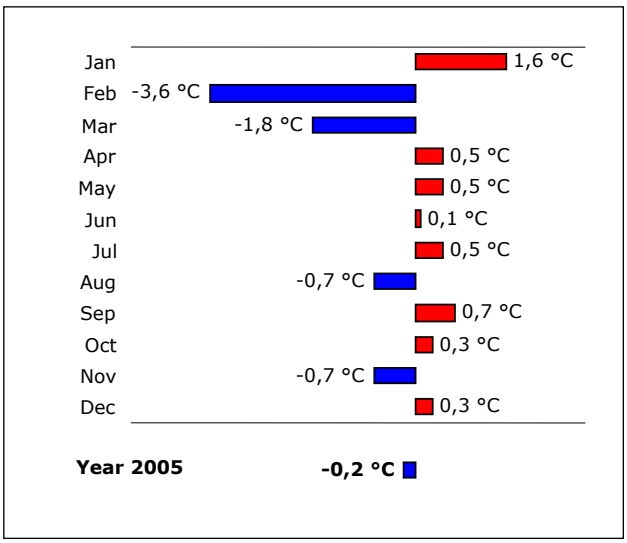

Figure 1.4. *Anomaly of the countrywide monthly mean temperatures 2005 (ºC) in Hungary*

In 2005 the number of the temperature threshold days was generally around the average of many years: the number of warm threshold days was a bit under the normal value, while that of the cold threshold days exceeded it a bit. The CDD value was definitely below average as it can be seen on *Figure 1.3.*

1.2. Institutional arrangements

The Minister for Environment and Water has overall responsibility for the Hungarian Greenhouse Gas Inventory and the Hungarian National System for Climate Reporting. He is responsible for the institutional, legal and procedural arrangements for the national system and the strategic development of the national inventory. Therefore the designated *single national entity* is the Ministry of Environment and Water. Within the ministry, the Climate Change and Energy Department administers this responsibility by supervising the national system.

Based on a mandate of the minister, a Greenhouse Gas Inventory Division (GHG division) was established in the Hungarian Meteorological Service (OMSZ) for the preparation and development of the inventory. This division is responsible for all inventory related tasks, prepares the greenhouse gas inventories and other reports with the involvement of external institutions and experts on a contractual base and supervises the maintenance of the system. It must be emphasized however, that the 2006-2007 inventory cycle is a period of transition with a shared responsibility of inventory preparation between the former (Ministry of Environment and Water) and the new (OMSZ) team.

The GHG division can be regarded as a core expert team of four people. The division of

labor and the sectoral responsibilities within the team are laid down in the QA/QC plan and other official documents of OMSZ. The Head of Division coordinates the teamwork and organizes the cooperation with other institutions involved in inventory preparations. He is responsible for compilation of CRF tables and NIR. Within the team there are coordinators of different sectors and a QA/QC coordinator and an archive manager are nominated as well.

The Hungarian Meteorological Service is an institute of the central government under the supervision of the Ministry of Environment and Water. The duties of the Service are specified in a Government Decree from 2005. The financial background of operation is determined in the Finances Act. OMSZ has introduced the quality management system ISO 9001:2000 for the whole range of its activities in 2002 to fulfill its tasks more reliably and for the better satisfaction of its partners. It can be seen from the organizational chart that the GHG Inventory Division is reporting directly to the president of the Service.

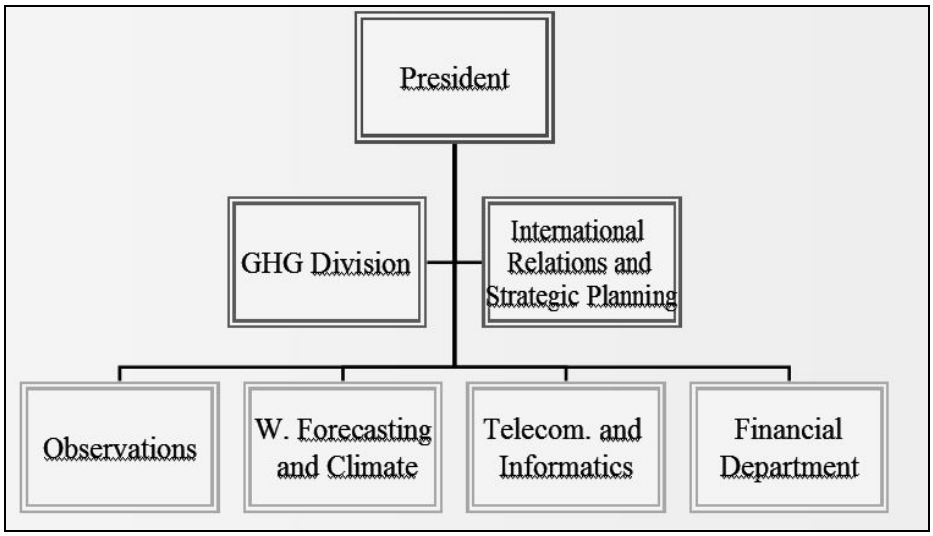

Figure 1.5. *Organizational chart of the Hungarian Meteorological Service*

GHG division coordinates the work with other involved ministries, government agencies, consultants, universities and companies in order to be able to draw up the yearly inventory report and other reports to the UNFCCC and the European Commission. The roles and responsibilities during the inventory preparation process have been shared between the following main players in the last two years.

The core team responsible for compiling the inventory consisted of two persons in the Ministry of Environment and Water till autumn of 2006. In the preparation of the 2005 inventory the Hungarian Meteorological Service has been involved and in the future the Service will be responsible for all aspects of the inventories. However, all the contracts for the 2005 inventory were concluded with the Ministry of Environment and Water as follows:

In the energy sector the Research Institute for Environmental and Water Management

(VITUKI) has been taken the responsibility on contractual basis with the ministry. VITUKI had to collect the data, prepare the Inventory in CRF format and send it to the inventory compiler in xml format. In addition, VITUKI had to formulate the Chapter Energy of the National Inventory Report. In the industry and solvent sector the main inventory compiler acted as sectoral expert as well, so he collected the data and prepared the inventory. The part Agriculture of the inventory was prepared by the Research Institute for Animal Breeding and Nutrition on contractual basis. This institute collected the data, chose the calculation method, prepared the inventory in CRF format and sent it to the Inventory compiler in xml format. In the part Forestry of the LULUCF sector an internationally recognized expert was responsible for data collection, inventory preparation. For the part Soil VITUKI again was the responsible institution. However, they contracted an external expert for this job. The Wastewater category of the inventory was basically done on contractual basis by VITUKI. They collected and analyzed the data and made some pre-calculations. However, the CRF tables were filled in by the core team. The solid waste disposal and waste incineration were prepared by the core team. The following table summarizes the institutional arrangements:

Function	***Institution***	***Responsibilities***
Single national entity	Ministry of Environment and Water	• Supervision of national system • UNFCCC National Focal Point • Official consideration and approval of inventory • Reporting to UNFCCC secretariat
Inventory coordination and compilation	OMSZ GHG division Ministry of Environment and Water (until 2007)	• Provision of workplan, • Contracting consultants • Inventory preparation of Industry and Waste sector • Completition of CRF and NIR • Archiving • Coordinating QA/QC activities
Inventory preparation of: Energy sector Soil subsector Wastewater subsector	Research Institute for Environmental and Water Management	• Data collection, choice of methods and EFs, inventory preparation • Involving subcontractors
Inventory preparation of Agriculture sector	Research Institute for Animal Breeding and Nutrition	• Data collection, choice of method, emission calculation • Inventory preparation
Inventory preparation of Forestry	Contracted consultant	• Data collection, emission estimation • Inventory preparation

Some of the employees making the inventory have a decade of experience in preparing emissions inventories.

1.3. Inventory preparation

The annual inventory cycle is carried out in accordance with the principles and procedures set out in the IPCC (1996) Guidelines and the IPCC Good Practice Guidance. The annual inventory starts in August each year and contains the following elements:

Data collection and processing

Data collection happens in several ways and throughout the whole yearly cycle of the inventory. Sector specialists of the core team (or external experts on contractual basis) are making the data inquiry and collection with the assistance of the Ministry for Environment and Water. Data are collected from the emitter if it is possible (especially in case of power stations, heating stations and industrial technologies) but statistical databases are also heavily used as source of information. The most important statistical publications are the Statistical Yearbook of Hungary, the Environmental Statistical Yearbook of Hungary both published by the Hungarian Central Statistical Office (HCSO) and the Energy Statistical Yearbook published by the Energy Efficiency, Environment and Energy Information Agency.

As inventory preparation develops, more and more sources of information are used. In addition to statistical data, we established contacts with the representatives of a number of major emitting sectors and used the data supplied by or coordinated with them for the preparation of the inventories. These sectors include aluminium production, the cement sector and the oil/gas sector. Moreover, information from the web sites of international associations (e.g., International Iron and Steel Institute, IISI) are used as well. For the calculation of fluoride gas emissions, the import data were provided by the Customs Office and Police (such gases are not manufactured in Hungary). Accordingly, the required data were obtained directly from companies importing and using fluorinated gases, and these were completed with information obtained from cooling industry associations. Further sources of information included the Good Practice Guidance, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the Background Paper published by IPCC.

As far as possible, data are obtained from published sources. Where such published sources are not available, we request written data supply (i.e., by mail, E-mail or fax). Information is sometimes obtained by telephone, especially in case of supplementary information. Data are used after quality control. Hungary is a small country and several technologies are used at only one or a few locations. Therefore, some of the data should be treated as confidential. Where the supplier requested, emissions from such sources are given only as aggregated values.

The Act on Implementation Framework for UNFCCC and its Kyoto Protocol, which has been passed by the Parliament recently, aims to give direct data collection authorization to the

Ministry for Environment and Water in order to collect data for the national system for climate reporting and will give a permanent status to the system. Relevant paragraphs for are the following: “All data required for the national system held by governmental institutions and all information about emissions more than 100 tons of CO2-eq held by emitters shall be made available for the national system…the relevant data shall be made available even if they are confidential according to the Law on Statistics…”

Method and emission factor selection

Basically, the sectoral experts are responsible for the choice of methods and emission factors. The calculation method – allowing for a few exceptions – was chosen by taking into account the technologies available in Hungary and according to the recommendations of the IPCC Guidelines. The calculation of the emissions occurs by using the formula:

Activity data X emission factor

where the activity data can be raw material or product or even primary product. In several cases emissions were determined in a different way, on the basis of other information. In the beginning, default emission factors were used but later on country-specific emission factors characteristic of domestic technologies were gradually introduced and replaced the default values.

Preparation of emission estimates

After preliminary quality control of the basic data, the necessary calculations are carried out with the coordination of the core team. The sectoral data are compiled and after repeated checks unified by using the CRF Reporter program.

Uncertainty assessment

The uncertainty values of the entire inventory are calculated on the basis of the method provided in the GPG.

Key source categories

The key source categories are determined by the method provided in the GPG at Tier 1 level and also at Tier 2 level using uncertainty data.

Recalculations

The team uses the same emission calculation procedures and factors for the full time-series whenever possible. Should new information emerge that improve the quantity, quality or accuracy of the emission data, the full time-series of emissions are recalculated.

Reporting

Collaterally with the compilation of the database but at the completion thereof the inventory report will be established with the content approved by the COP. In this report the steps of inventory-making, the basic data, the chosen calculation method are to be presented, the results and the emission trends will be assessed, etc.

Submission and approval

About two weeks before submission, the complete NIR has to be sent to the sectoral experts for a final check. After that, the Climate Change and Energy Unit that supervises the core team approves the documents to be submitted.

Review

For the reviews performed by the UNFCCC Secretariat all the necessary information is provided. In case of detected problems, recalculation is performed or the next inventory is compiled by taking into account the reflections and proposals of the review team.

Archiving

A copy of all data, information necessary for the compilation of the given annual inventory is stored in printed or electronic form either by the expert team or by the institutions involved in inventory preparations. Significant steps were taken to create a central archive in the premises of the Hungarian Meteorological Service where all background data would be stored.

The most important paper information archived already in the Service is the following:

- Statistical Yearbooks of Hungary from the year 1961
- Environmental Statistical Yearbook of Hungary from 1996
- Energy Statistical Yearbook published by the Energy Efficiency, Environment and Energy Information Agency from 1985.
- National, regional and local emission survey of the Hungarian road, rail, water-borne and air transport (1995-2004) made yearly by the Institute of Transport Sciences

Lots of background data are stored by contracted expert institutions as well, which increases the security of data availability. Nevertheless, at least a copy of all information will be transferred to OMSZ in the near future. The following information is stored elsewhere:

- Former inventories, NIRs and CRFs – Ministry of Environment and Water
- Data from individual industrial plants - Ministry of Environment and Water
- ETS data, registry - National Inspectorate for Environment, Nature and Water
- Agricultural data (livestock, manure, fertilizer etc.) - Research Institute for Animal Breeding and Nutrition
- Soil-classification - Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (TAKI)
- Land-use and tillage data, lime consumption - Agricultural Economics Research Institute (AKI)
- Forestry statistics - State Forest Service (ÁESZ)
- Wastewater data - National Inspectorate for Environment, Nature and Water +

Research Institute for Environmental and Water Management.

Electronic information is stored on disks on a fileserver with a regular backup. The whole data files are backed up once a week, while the implements (those files that have been modified since the last saving) are saved two times a week. The data are stored on tape storage system in the informatics system of OMSZ. The cassettes of the data storage system are stored far from the recording system, in another room, which is air conditioned and equipped with an up-to-date fire service system. All events connected with the data saving are logged in accordance with the documents of the Quality Assurance System of OMSZ.

The directories of the server, where the data of the GHG Division are stored have access protection, so they are available only for the staff of the Division in charge of the different sectors of the GHG inventory.

The structure of the GHG Division's data is as follows:

- Data requests and supply (with the relevant contracts)
- Documentations
- Xml files
- Calculations, background information
- Reports
- Literature
- QA/QC information
- Working folder

It is important to note that there are different directories for all the calculations and drafts (working folder) and for the submitted reports and incoming data which cannot be modified.

Within the GHG Division of OMSZ, there is a nominated archive manager who is responsible for the maintenance of the archiving system in close cooperation with the IT Department of the Service. A procedural manual for the management and maintenance of archiving system is under preparation.

A harmonized or maybe unified computerized database containing all the data relevant to the National System as well as for the EU emission trading regime is under development. Further development of the system may include the incorporation of other emission data, which are relevant to air pollution.

10. Art. 8 reviews

Expert reviews will be conducted yearly. The review teams will receive full access to the data and documents used for the preparation of the inventory and other reports, and the team (internal and external experts) responsible for the preparation of the given report will be available for inquiries.

Verification

The verification of the inventories already begins in the data collection stage. Data are verified by comparing several databases, in other cases the received information is checked by statistical data. Verification is performed by the experts and the compiler of the inventory on the one hand on the basis of the already long time series and on the other hand by comparing with the emission database.

1.4. Methodology

As general method of preparing the inventory, the procedure described in the Revised 1996 IPCC Guidelines (hereinafter referred to as ”Revised Guidelines”) and – in part – the software programme developed by IPCC were used. Part of the available data (e.g. production data) could be directly entered into the IPCC tables; others required previous processing and conversion. For example, energy data are not always available in the required depth and resolution. Usually, the tables for individual sectors were filled with the activity data, and specific emission factors for Hungary were determined on the basis of the guides, and also these factors were entered into the IPCC tables. In other cases, default specific emission factors were used. The results of the calculations and the required basic data were directly entered into the tables of the CRF Reporter. The resulting CRF tables were obtained as the output of this software programme.

The emissions of individual technologies are calculated using the Tier 1, Tier 2 or Tier 3 method, attempting at the highest possible approximation except for the cases where the required data are not available. (See CRF Inventory, Summary Table 3.)

Methods other than the standard ones were used for the calculation of

- methane emissions for oil/gas mining,
- methane emissions from wastewater sludge,
- solvent uses (no method is available),
- HFCs and SF_6 gases.

We were forced to apply such deviations primarily due to the insufficient or different availability of data/information.

Before, only a few specific emission factors were available for Hungary. In addition to the recalculations, our objective was to determine the specific emission factors for the key categories. Where such specific emission factors became not available, the default values recommended by the guidebooks were taken, mostly using the values proposed for Eastern European technologies. However, where advanced technologies similar to those of the Western European countries were adopted, the values proposed for such technologies were used. In cases where intervals were provided as specific values, we usually used the arithmetical means. For certain technologies (e.g., aluminium production, CF_4 emission), the

specific emission typical for the Hungarian manufacturing processes was determined on the basis of the Revised Guidelines. For the calculation of the emissions of 1980's and 1990, we had to rely on expert estimates for missing data.

1.5. Key source categories

Key sources have been identified using the Tier 1 methodology in accordance with the guidance of the GPG for several years. This analysis has been completed with the Tier 2 methodology since last year. The required uncertainty values were determined on the basis of the GPG, and estimates of the data supplier institutions and experts were used as well. For the calculations all greenhouse gases and sectors were taken into account. In order to identify the key categories, both the LEVEL and the TREND analysis were performed with and without LULUCF.

As a result of calculation without LULUCF, 17 key source categories using LEVEL Tier 1 method and 14 key source categories using TREND Tier 1 method were identified. The key source categories are shown in *Annex 1.4, Table A1-8*.

Whereas the most important emitting technology continues to be the "Stationary Combustion – Gas" (CO_2, 35%), "Fugitive Emissions from Coal Mining and Handling, CH_4" has the lowest contribution (CO_2 eq., 0.027%) among the key sources. The latter was included in this group despite its low contribution as determined by the TREND method because there was a significant difference in emissions between the base year and 2005.

Using the concept of "Combined uncertainty" from the Tier 2 methodology, LEVEL 2 and TREND 2 key sources were also identified. Both consisted of 13 source categories.

Results of key category calculation with LULUCF are summarized in *Table 1.1*. Since uncertainty estimates are not available for the LULUCF sector, Tier 2 method was applied to find key categories only for source categories (without LULUCF). The LEVEL and TREND methods found 19 and 17 key categories, respectively.

Detailed description from key category analysis can be found in Annex 1.

Table 1.1. *Key category analysis summary – with LULUCF*

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF

Quantitative Method Used: [X] **Tier 1** [ ] **Tier 2**

A	B	C	D	E
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
1. Energy				
Stationary Combustion - Gas	CO_2	Yes	Level 1, Trend 1	
Stationary Combustion - Coal	CO_2	Yes	Level 1, Trend 1	
Stationary Combustion - Oil	CO_2	Yes	Level 1, Trend 1	
Non-CO_2 Emissions from Stationary Fuel Combustion	N_2O	Yes	Level 1	
Non-CO_2 Emissions from Fuel Combustion	CH_4	No		
Stationary Combustion - Other Fuel	CO_2	No		
Mobile Combustion	N_2O	No		
Mobile Combustion - Other	CO_2	Yes	Trend 1	
Mobile Combustion	CH_4	No		
Mobile Combustion - Road	CO_2	Yes	Level 1, Trend 1	
Fugitive Emissions from Coal Mining and Handling	CO_2	No		
Fugitive Emissions from Coal Mining and Handling	CH_4	Yes	Trend 1	
Fugitive Emissions from Oil and Gas Operations	CO_2	No		
Fugitive Emissions from Oil and Gas Operations	CH_4	Yes	Level 1, Trend 1	Main Source: Gas Distribution
2. Industrial Processes				
N_2O Emission from Industry	N_2O	Yes	Level 1, Trend 1	
CH_4 Emission from Industry	CH_4	No		
CO_2 Emissions from Cement Production	CO_2	Yes	Level 1	
CO_2 Emissions from Lime Production	CO_2	No		
CO_2 Emission from Limestone and Dolomit Use	CO_2	No		
CO_2 Emission from Other Mineral Products	CO_2	No		
CO_2 Emissions from Ammonia Processes	CO_2	Yes	Level 1, Trend 1	

Table 1.1. *Key category analysis summary – with LULUCF*

SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF

Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**

A	B	C	D	E
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
2. Industrial Processes				
CO_2 Emissions from Metal Production	CO_2	No		
PFCs Emissions	PFCs	No		
Emissions from Substitutes for Ozone Depleting Substances	HFCs	Yes	Level 1, Trend 1	
SF_6 Emissions from Electrical Equipment	SF_6	No		
3. Solvent and Other Product Use				
CO_2 Emission from Solvent and Other Product Use	CO_2	No		
N_2O Emission from Solvent and Other Product Use	N_2O	No		
4. Agriculture				
CH_4 Emissions from Enteric Fermentation in Domestic	CH_4	Yes	Level 1, Trend 1	
CH_4 Emissions from Manure Management	CH_4	No		
N_2O Emissions from Manure Management	N_2O	Yes	Level 1, Trend 1	
CH_4 Emission from Rice Cultivation	CH_4	No		
Direct N_2O Emissions from Agricultural Soils	N_2O	Yes	Level 1, Trend 1	
Animal Production	N_2O	No		
Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	Yes	Level 1, Trend 1	
Field Burning of Agricultural Residues	CH_4	No		
N_2O Emissions from Agricultural Residue Buming	N_2O	No		
5. Land Use. Land-Use Change and Forestry				
Forest Land Remaining Forest Land	CO_2	Yes	Level 1, Trend 1	
Forest Land Remaining Forest Land	CH_4	No		
Forest Land Remaining Forest Land	N_2O	No		
Conversion to Forest Land	CO_2	Yes	Level 1	
Croplands Remaining Croplands and Emission from Lime	CO_2	No		
Conversion to Grassland	CO_2	No		
5. Land Use. Land-Use Change and Forestry				

Table 1.1. *Key category analysis summary – with LULUCF*				
SOURCE CATEGORY ANALYSIS SUMMARY – WITH LULUCF				
Quantitative Method Used: ☒ **Tier 1** ☐ **Tier 2**				
A	**B**	**C**	**D**	**E**
IPCC Source Categories	**Direct Greenhouse Gas**	**Key Source Category Flag (Yes or No)**	**If C Yes. Criteria for Identification**	**Comments**
Conversion to Other Land	CO_2	Yes	Level 1, Trend 1	
6. Waste				
CH_4 Emissions from Solid Waste Disposal Sites	CH_4	Yes	Level 1, Trend 1	
Emissions from Wastewater Handling	CH_4	Yes	Level 1	
Emissions from Wastewater Handling	N_2O	No		
Non-biogenic CO_2 from Waste	CO_2	No		
N_2O Emissions from Waste Incineration	N_2O	No		

1.6. QA/QC information

The national system has to ensure high quality in the inventory, i.e. to ensure that the inventory is transparent, consistent, comparable, complete and accurate. These terms are defined in the UNFCCC guidelines on yearly inventories (FCCC/CP/2002/8). These principles guide the internal expert team maintaining the system.

The external experts involved in inventory preparation have prepared or have participated in the preparation of national databases (emission databases, pollution databases) for several years and members of the team have “expert permissions” issued by the Minister for the Environment and Water, which were only granted to staff members with sufficient experience and trustworthiness. New team members are subject of thorough on hand training which lasts for two inventory circles.

QA/QC activities are performed in two levels: based on the ISO 9001 standards and following the IPCC recommendations.

ISO activities

The Hungarian Meteorological Service introduced the quality management system ISO 9001:2000 in 2002 for the *whole range* of its activities which was quite unique among meteorological services. However, GHG inventory preparation was not among its activities in that time. Therefore, the scope of our ISO accreditation had to be modified and lots of efforts have been made to bring also the national system under the umbrella of the ISO QM system.

Several regulatory ISO documents were created, among others:

- ISO procedure on the activities of the GHG Division
- QA/QC plan
- Register of used data, data sources and calculation methods
- Record of data changes
- Register of recalculations
- Record of data quality check

The basic document is the Procedure on the activities of the GHG Division. It contains the basic principles of the inventory preparation and reporting processes, prescribes the obligation of making a QA/QC plan, regulates the documentation and archiving activities. Our first QA/QC plan, which is an audited ISO document, consists of the following elements:

- Specification of the sectoral responsibilities of the core team
- Nomination of an officer responsible for the QA/QC system: the QA/QC coordinator
- Documentation. All data, data sources and calculation methods need to be documented by the sectoral experts of the core team filling in an ISO form. Based on this documentation, sectoral reports will be written about the status of the sector and possible future improvements.
- Data quality check. Besides self-checking, the entries of data providers and external experts are checked regularly which is an interactive process during the whole inventory cycle. Significant changes compared to previous data shall be explained. A spreadsheet for documenting these quality checks is in testing phase.
- Reviews. Three external reviews were planned for the first half of this year. An in-country review by UNFCCC Secretariat, an ISO audit and an in-depth analysis of the inventory by a firm with experience in inventory preparation.
- Development plan. Based on the outcome of all reviews and own experience, a development plan will be made by the end of July, before the start of the next inventory cycle to further improve the system. For this purpose, a workshop will be organized for all data providers and experts involved in the inventory preparation to survey the current situation, search for possibilities of improvement and facilitate the cooperation between the institutions.
- The Hungarian Meteorological Service funds three research and development projects for the improvement of the inventory. A better forestry database will be developed by the State Forestry Service, the Research Institute for Animal Breeding and Nutrition will work on country specific emission factors, and we will have better wood density data from the Forest Research Institute.
- Training. Since the further education of the core expert team is important, members of

the team are visiting the relevant course at the Budapest Technical University.

Our current QA/QC plan is valid until August 15, 2007, so for the next inventory cycle a new plan will be made.

Having an ISO system in place has an advantage of being subject to regular internal and external audits. During our last external audit the activities of the GHG Division were audited as well. Our system was audited favourably in the end of March, therefore we can claim that the GHG inventory is subject to ISO 9001:2000.

Other QA/QC activities

Although not documented, many elements of the general Tier1 QC procedure are applied. The used parameters and factors, the consistency of data are checked regularly. Completeness checks are undertaken and previous estimates are compared every time. Data entry into the database is checked many times by a second person.

Activity data: The major part of the basic data related to key source categories was obtained directly from the plants, therefore, we use the latest and most reliable data. Where such data are not available, those from the Central Statistical Office are used. In order to prepare an inventory of appropriate quality, the data were checked in several ways (e.g., production plant and professional association). The results were controlled by comparing the time series, which was much more possible now, upon having a complete time series available. In order to ensure data accuracy, cross-checks were performed. In response to our request, several data suppliers made declarations as regards quality assurance systems in place during the collection of the data. However, only a few of them could provide factual information on the reliability of the data supplied.

Emission factors: The emission factors were selected in accordance with the Revised 1996, the GPG and the new 2006 Guidelines. The quality of the inventory has been greatly improved by the use of national factors in increasing numbers. The shift to annual average livestock in agriculture and the use of factors better reflecting the Hungarian conditions have greatly improved the quality of the inventory.

Checking: The results of the calculations and the implied emission factors are checked and considerable differences, if any, are revised again. The modifications and improvements from the previous year are documented and recorded in the NIR.

Another factor improving the quality is that most of the corrections proposed by the UNFCCC ERT reports have been completed.

The national system's quality system is based on the structure described in UNFCCC decision 19/CPM.1. The structure complies with the PDCA cycle (Plan, Do, Check, Act), which is an adopted model for how systematic quality and environmental management activity is to be undertaken according to international standards in order to ensure that quality

is maintained and developed.

Budget line is maintained for the external quality assurance of the reports prepared within the framework of the National System.

The work continues to refine the used QA/QC procedures and implement further elements.

1.7. Uncertainty

The reliability of the data for individual source categories was estimated on the basis of the GPG but information from the industry and expert estimates was also used primarily in the case of key source categories. In a number of cases, the level of uncertainty was also characterised in words. Regardless of the actual values obtained, it can be generally stated – like before – that the most reliable data are those of CO_2 emissions and the least reliable ones are those of N_2O emissions.

In summary, the reliability of the inventories can be characterised as follows:

The CO_2 calculation has the highest reliability and has a weight of 77.02% in the total emission (in CO_2eq.). The least reliable is N_2O calculation representing 12.1%. CH_4, which has a medium reliability, has a similar proportion (9.72%). Fluoride gases are irrelevant here because their contribution to the total emission in only 1.16%. Accordingly, the *estimated* uncertainties of the emissions of different gases are as follows:

CO_2	±2-4%
CH_4	±15-25%
N_2O	±80-90%

Previously, the uncertainty of the total emission was estimated as less than 10%. After evaluating the complete time series (1985-2005), the uncertainties and the calculation errors of the inventories were further reduced.

On the basis of Table 6.3 of the GPG we have determined the total uncertainty according to the Tier 1 method. Accordingly, the combined uncertainty as % of total national emissions (in the year 2005) is 5% and the uncertainty introduced in trend in national emissions is 2.5%.

1.8. Completeness

During the preparation of the inventories, we do our best to fill the tables as complete as possible. Although GHG inventories have been prepared year by year since 1994, the consistency of the inventories could be reached only by 2005 for the whole time series (1985-2003). We have met all the changing requirements but there were delays due to our limited human resources. However, we could not determine so far the quantities used in fire extinguishing systems but made advances in specifying the fluoride gases used for foaming. Based on our preliminary enquiry, these have no significant effects on the inventory as a

whole. We made sure that if new information becomes available during the preparation of the inventory or the method is modified on the basis of previous experience, these also appear in the inventories of the previous years.

Following the recommendations of the ERT, the recalculation efforts were concentrated on the base year and 2004. Therefore, a fully consistent time series of inventory data will be available only in the next submission.

2. TRENDS OF GHG EMISSION

In the United Nations Framework Convention on Climate Changes, Hungary undertook to keep its CO_2 emissions in 2000 at or below the 1990 level. In the Kyoto Protocol, we committed to reduce the average greenhouse gas emission by 6 % of the base year level during the five years of the first commitment period (2008 to 2012). It will be shown in the next Sections that Hungary has complied with these commitments.

2.1. Total GHG emission

The trends of the total greenhouse gas emissions may be assessed on the basis of the GWP. It should be noted that CH_4 and N_2O emissions in road transport category between 1988 and 2003 are not consistent with emissions from other years. The table below shows the time series of net and gross emissions:

GREENHOUSE GAS EMISSIONS CO_2eq	AY*	BY**	1990	1991	1992	1993	1994	1995	1996
Total including net CO_{2eq} from LULUCF	112,564	112,454	94,230	85,534	75,524	74,277	73,428	71,299	77,645
Total excluding net CO_2 from LULUCF	115,715	115,604	98,137	89,851	80,773	81,159	80,817	79,241	81,399

GREENHOUSE GAS EMISSIONS CO_2eq	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total including net CO_{2eq} from LULUCF	75,707	73,715	77,312	75,441	75,599	73,926	75,480	74,735	75,743
Total excluding net CO_2 from LULUCF	79,442	78,976	79,132	77,340	79,111	77,054	80,284	79,204	80,248

Table 2.1. *Total GHG emissions including and excluding CO_2 from LULUCF*

**AY =average of 1985-87 and ** BY=average of 1985-87 but 1995 for F-gases*

The figure below shows the net emissions from the base year until the last year assessed, taking also removals into account. The straight line in the figure indicates the reduction target.

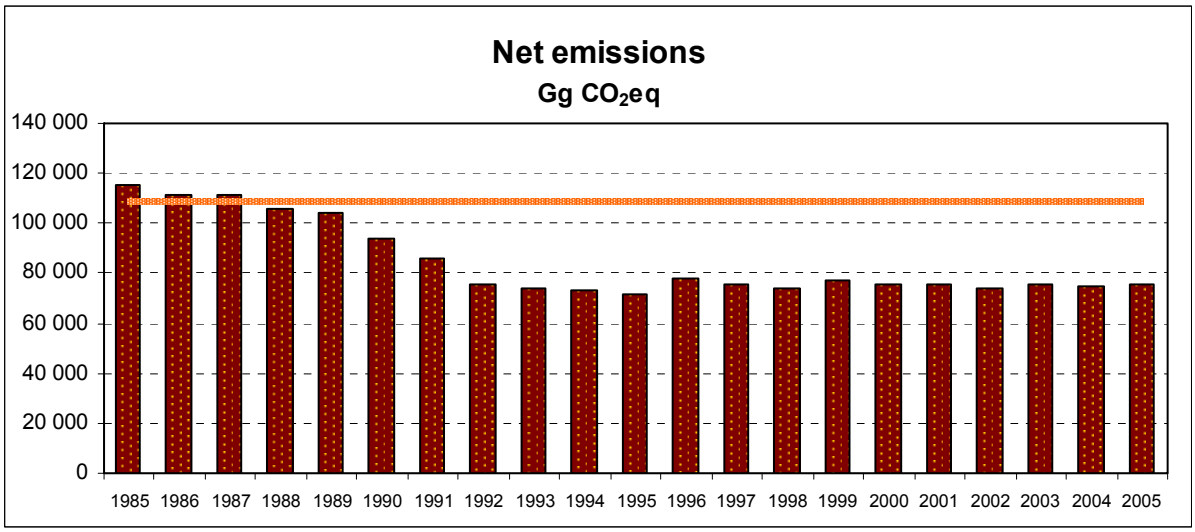

Figure. 2.1. *Total emission (including net CO_2 from LULUCF) between 1985-2005*

Upon the collapse of the centralised planned economy, economic production was significantly decreasing until the mid 1990's, which was also reflected in the emission levels. Subsequently, by the end of the decade, emission levels began to rise slightly as a result of the transition into a market economy. These are illustrated in the figure below:

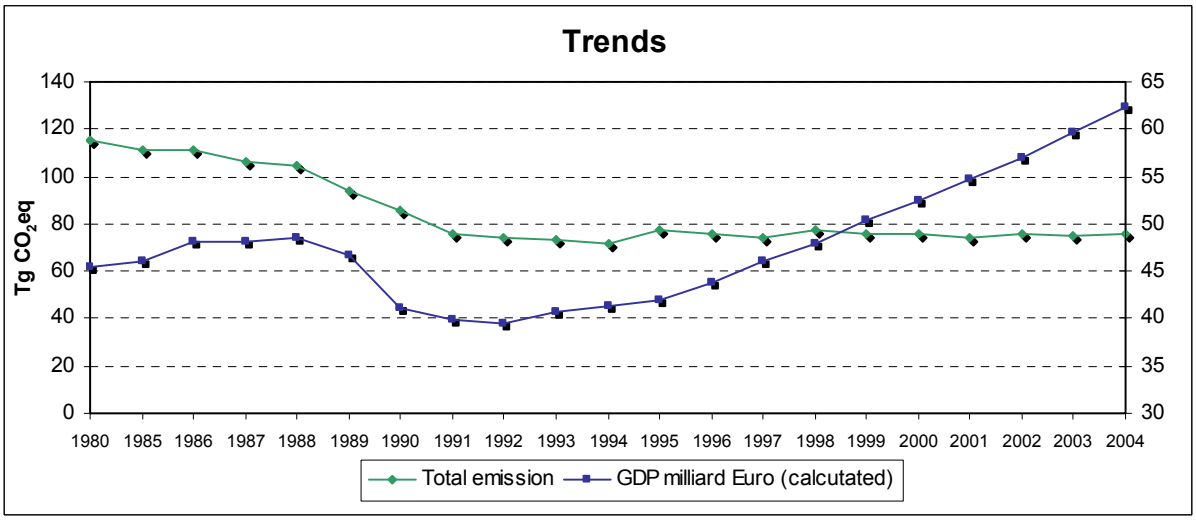

Figure 2.2. *Trends in Emissions of greenhouse gases and GDP*

As the figure shows, by 1999, the GDP reached the pre-1990 level; however, emission levels remained significantly below the levels of the preceding years.

2.2. Trends by GHG

The tables below show the emission data for each gas (Gg CO_2 equivalent):

GREENHOUSE GAS EMISSIONS	AY*	BY**	1990	1991	1992	1993	1994	1995	1996
CO_2 emissions without LULUCF	85,969	85,969	73,190	69,304	62,867	63,711	62,598	61,940	63,290
CH_4 emissions without LULUCF	10,139	10,139	9,455	9,282	8,581	8,304	8,147	8,217	8,313
N_2O emissions without LULUCF	19,224	19,224	15,152	10,951	9,116	8,925	9,821	8,821	9,540
HFCs	0.0	1.7	0.0	0.0	0.0	0.1	1.1	1.7	1.6
PFCs	268.5	166.8	270.8	233.7	134.8	145.7	158.9	166.8	159.4
SF_6	81.0	70.1	39.9	52.7	49.0	51.8	67.9	70.1	69.0

GREENHOUSE GAS EMISSIONS	1997	1998	1999	2000	2001	2002	2003	2004	2005
CO_2 emissions without LULUCF	61,553	60,790	60,708	58,931	60,343	58,762	61,912	60,267	61,808
CH_4 emissions without LULUCF	8,248	8,261	8,271	8,269	8,094	8,089	8,075	7,836	7,777
N_2O emissions without LULUCF	9,340	9,512	9,443	9,553	10,059	9,449	9,418	10,167	9,707
HFCs	45.2	125.1	347.3	205.7	280.7	403.6	498.9	525.8	517.6
PFCs	161.4	192.6	209.6	211.3	199.1	203.3	189.6	201.1	209.4
SF_6	68.0	68.5	126.8	140.1	107.4	119.6	161.9	178.2	201.0

Table 2.2. *Trends in emissions of greenhouse gases in Hungary (1985-2005)*

**AY =average of 1985-87 and ** BY=average of 1985-87 but 1995 for F-gases*

The same is demonstrated by the figure below:

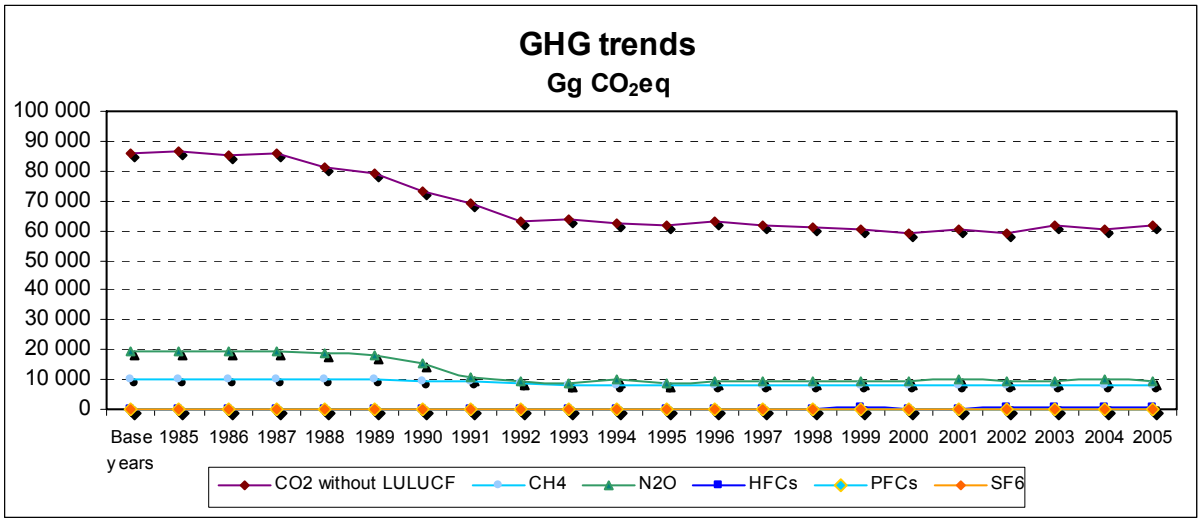

Figure 2.3. *Trends of greenhouse gas emissions.*

Note: BY=average of 1985-87 but 1995 for F-gases

The drop in CO_2 emissions during the early 1990's was attributable to the reduction of fuel

uses in conjunction with the national output. From the second half of the 1990's emissions show a stagnating or slightly decreasing tendency reflecting the effects of restructuring following the economic growth and those of the resulting fuel changes leading to a reduction in the specific emission levels.

As regards CH_4 emissions, two opposing effects should be considered. On the one hand, reductions in the livestock result in lower emissions. On the other hand, fugitive emissions increase as gas supply via pipelines becomes more and more widespread. This is the reason why the resultant trend is relatively stagnating but slowly decreasing.

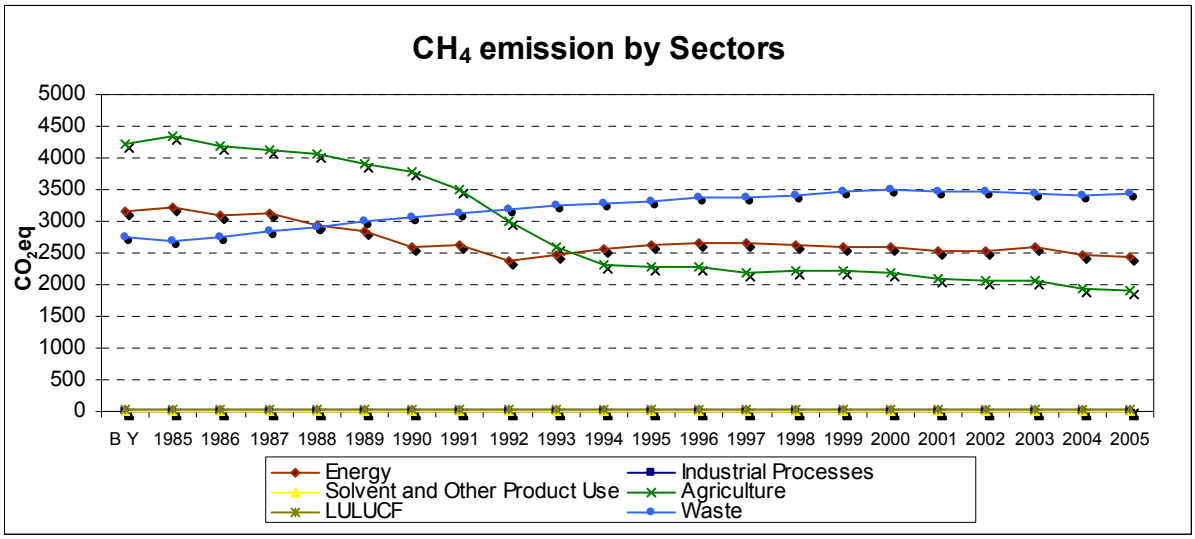

Figure 2.4. *CH_4 emission. Note: BY=average of 1985-87 but 1995 for F-gases*

Due to the above factors, N_2O emissions significantly decreased in the beginning of the period and then showed a slightly rising trend, followed by another drop primarily reflecting the fluctuations in agricultural output.

The use of HFC gases became more intensive in the second half of the 1990's in conjunction with the restriction of the use of chlorofluorocarbons as refrigerants. The rise is obvious. However, a saturation process has been observed in the past three years primarily due to the fact that household refrigerator manufacturing begins to discontinue their uses. In spite of this, use rates rose by almost 100% in 2003 with a further increase in 2004 also in the emission rates.

PFCs emissions are principally related to aluminium production processes. Therefore, the tendencies of PFC emissions reflect the changes in aluminium production. Following a drastic reduction in the beginning of the period, the levels show a slow but steady increase.

SF_6 emissions primarily depend on the uses in the power generation industry. The tendencies vary according to the manufacturing/application needs and show a steadily increasing trend.

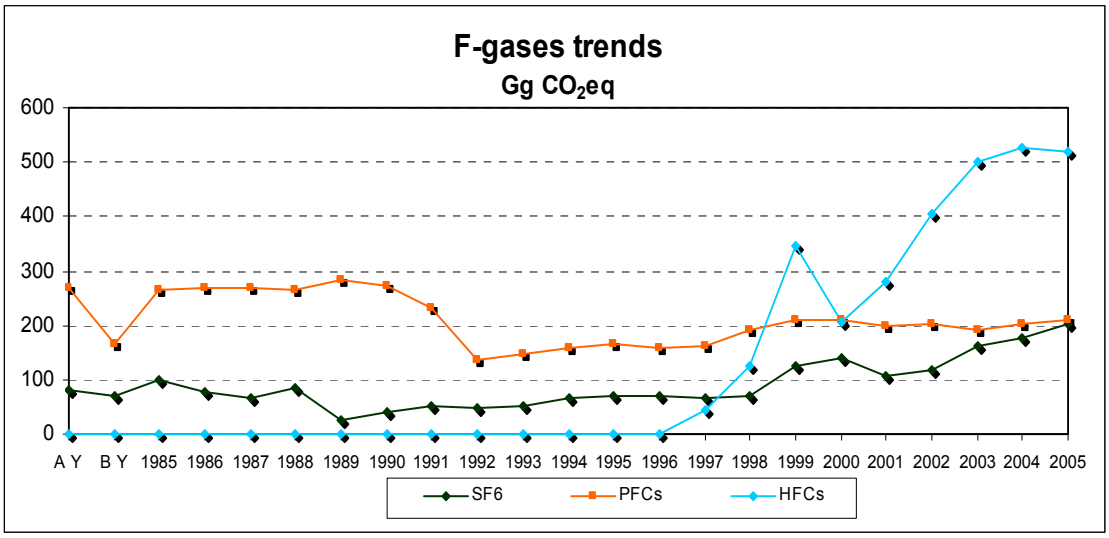

Figure 2.5. *F-gases trends Note: AY =average of 1985-87 and BY=average of 1985-87 but 1995 for F-gases*

2.3. Trends by sectors

The figure below shows the emissions by sources and removals by sinks for each sector. As demonstrated by the figure, Energy and Agriculture are the sectors with the greatest influence on the total emission.

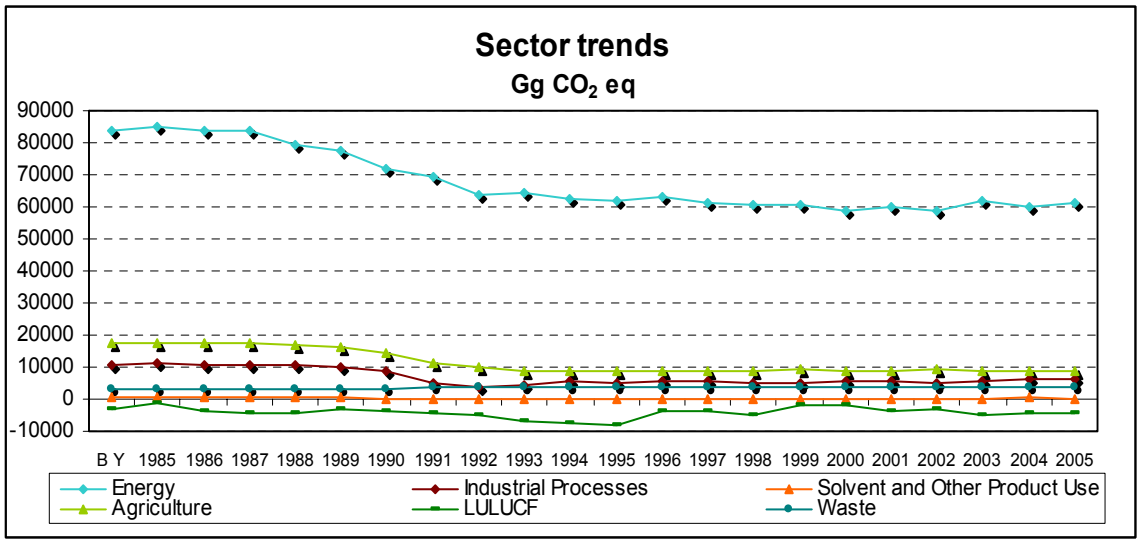

Figure 2.6. *Trends in emissions of greenhouse gases from each sector*

Note: BY=average of 1985-87 but 1995 for F-gases

Emissions by the Energy sector decreased in the first part of the period as a result of reduced energy consumption and use of fuels with more favourable composition. After 1994 emissions from energy sector are fluctuating around 61000 Gg in CO_2 equivalent. The

increasing energy demand and increasing emission in 2005 is due to the joint impact of several factors, such as less favourable weather conditions than in the previous year and the higher energy demand of Manufacturing Industries and Construction and Transport sectors. The decreasing emissions by the Agricultural sector are related to a remarkable reduction in livestock and plant production. In the second half of the period, agricultural emissions were fluctuating. The slight increase in 2004 is attributable to a yield that greatly exceeded that of the preceding years. The increase of emissions in the Waste sector is attributable to the slightly increasing quantities of waste generated and collected but more importantly to the applied calculation method which assumes that the degradable organic component in waste decays slowly throughout a few decades. The reduction in the LULUCF sector (increase in removals) is due to the increased number of trees. Emission or removal resulting from the changes in the CO_2 balance of the soil has considerable influence on the shape of the curve.

2.4. Trends of indirect gases and SO_2

Indirect gas emissions have been calculated in the national emission database (NED) for several decades and also in the CORINAIR for more than ten years. Since 1998, the CRF database has been loaded with data in line with these. Due to capacity problems, the CRF spreadsheets prepared for the preceding years had not been loaded with data for indirect gases as such data were otherwise available. Emission data for these gases are as follows (kt):

Indirect gases	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NO_X	262.5	264.2	264.9	257.8	246.8	238	203.1	183.3	184	187.4	190.07
CO	931.1	--	--	963.1	--	997	913.4	835.8	796.1	774.29	761.29
NMVOC	232	263	228	215	205	205	149.6	141.8	149	142.4	150.3
SO_2	1403.6	1361.8	1285.3	1218	1102	1010	913	827.3	757.3	741	704.96

Indirect gases	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
NO_X	195.81	199.5	202.62	197.4	185.1	183.2	183.0	210.7	185.3	203.1	
CO	726.87	733.36	736.93	592.4	592.4	578.8	573.8	600.3	585.4	585.2	
NMVOC	150.1	145.4	140.6	165.5	166.0	162.3	160.1	169.0	157.0	176.2	
SO_2	673.23	658.51	591.79	598.0	489.0	403.9	364.9	347.8	248.8	146.6	

Table 2.3. *Trends in emissions of indirect greenhouse gases and SO_2 The database is not complete for the beginning of the period.*

The significant reduction in sulphur dioxide is attributable to the reduction in fossil fuel uses, as well as to the decreasing sulphur content of these fuels. The further decrease in 2000 was

caused by the introduction of SO_2 precipitators in carbon-fuelled power stations. The decrease in carbon monoxide is the result of the reduction in the quantities of fuels used, as well as that of factory closings and technology changes in the preceding years. NO_X and NMVOC emissions show no significant trend in the last 15 years.

3. ENERGY (CRF Sector 1.)

Overview of the energy situation of Hungary in 2005

(Source: Energia Központ Kht., 2007)

The primary energy use of Hungary was 1153.2 PJ in 2005, by 6% higher than the use in 2004 (1088.1 PJ).

The increasing energy demand in 2005 is due to the joint impact of several factors, such as less favourable weather conditions than in the previous year and the higher energy demand of the industry:

- in the heating period the daily mean temperature was by 1.0°C lower than in the previous year, increasing the energy demand of heating by roughly 6%.
- the rising energy use of the industry is linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products (primarily glass) grew by 12.8% and the chemical industry by 6.4% (KSH, 2006). We must also highlight the 36.4% (nearly 24 PJ) increase in the use of petroleum products for non-energy purposes by the chemical industry and the construction industry compared to the previous year.

In addition to energy use, the economy also grew in 2005 by 4.2%, therefore the energy efficiency of the economy (energy use per unit GDP) declined by 1.7%.

To meet the total energy demand sources of 1160.8 PJ were available of which 36.9% came from domestic production (428 PJ, including 35.2% nuclear production) and 63.1% (732.8 PJ) was net imported energy.

Within energy use the share of coals continued to decline to 11.0% from 13.2% in 2004. The share of oil and petroleum products further grew from 23.7% to 25.8%, while the share of the other key energy type, gas decreased from 44.8% to 43.9%. Among primary electricity sources nuclear electricity accounted for 11.1% in 2005 and imported electricity represented 1.9% within the total primary energy use. The share of renewables' use increased from 4.0% to 4.3% in 2005. *Figure 3.1* shows the distribution of energy consumption during the last 16 years.

Use of natural gas was 14.98 billion m^3 in 2005 – 3.03 billion m^3 of domestic gas and 11.95 million m^3 of imports were available to ensure uninterrupted natural gas supply. Domestic gas consumption in Hungary has one of the highest shares in Europe (43.9%). In the structure of communal energy use natural gas represents 66.3%. 70% of households and institutions are supplied with natural gas.

In the field of environmental protection the growing use of renewables was a major step. Several power plants switched from coal to biomass. In addition, so-called co-burning in

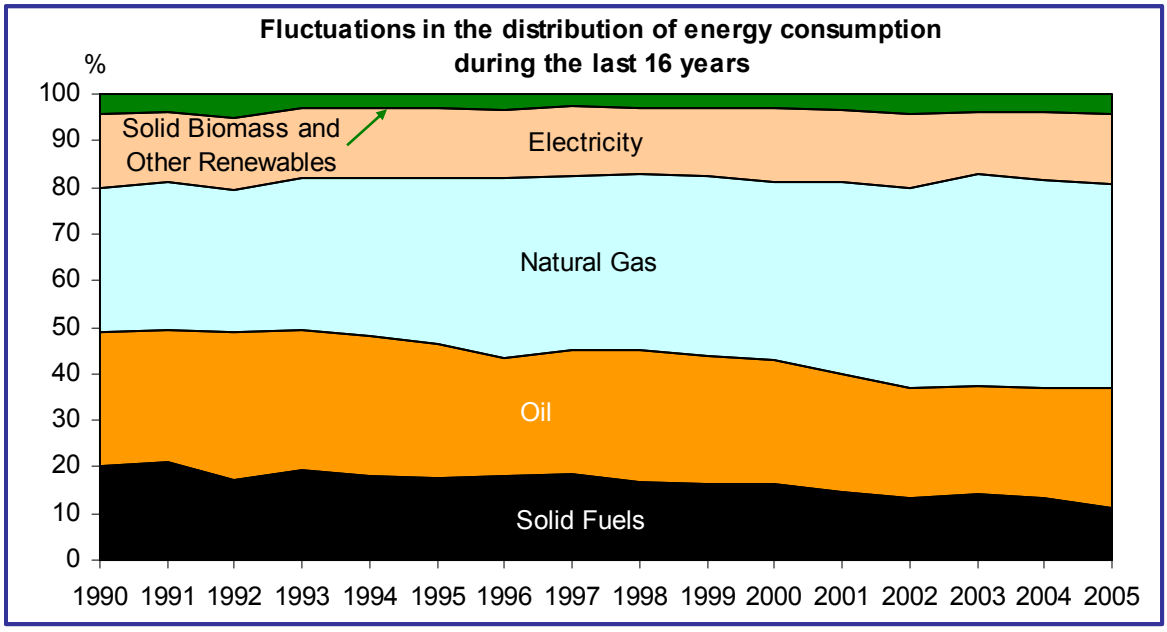

Figure 3.1. *Distribution of total energy consumption in Hungary during the last 16 years. Electricity means imported electricity and electrcity produced by nuclear power plant. (Source: Energia Központ Kht., 2007)*

coal-fired blocks became more frequently used. In 2005 approximately 4.2% of the total electricity demand of Hungary was met by electricity produced with renewables and waste. This figure is nearly the double of the previous year's value (2.3%).

Electricity produced from biomass and biogas accounted for 4.4% of domestic electricity. Electricity produced by hydro plants, wind and total renewables and waste represented together 4.9 % of electricity production.

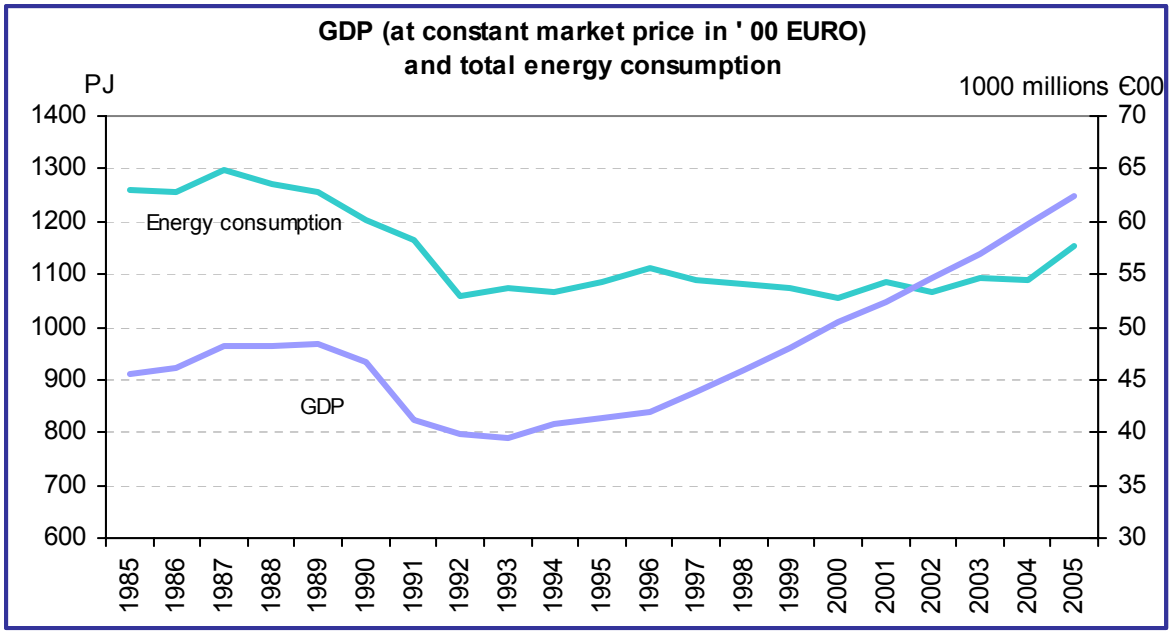

Figure 3.2. *GDP and total energy consumption in Hungary (1985-2005) (Source: KSH, 2006; Energia Központ Kht., 2007)*

3.1. Overview of the Sector

This sector covers fuel-related and fugitive emissions from combustion. *Figure 3.3* represents distribution of combusted fuel type in the base year and 2005.

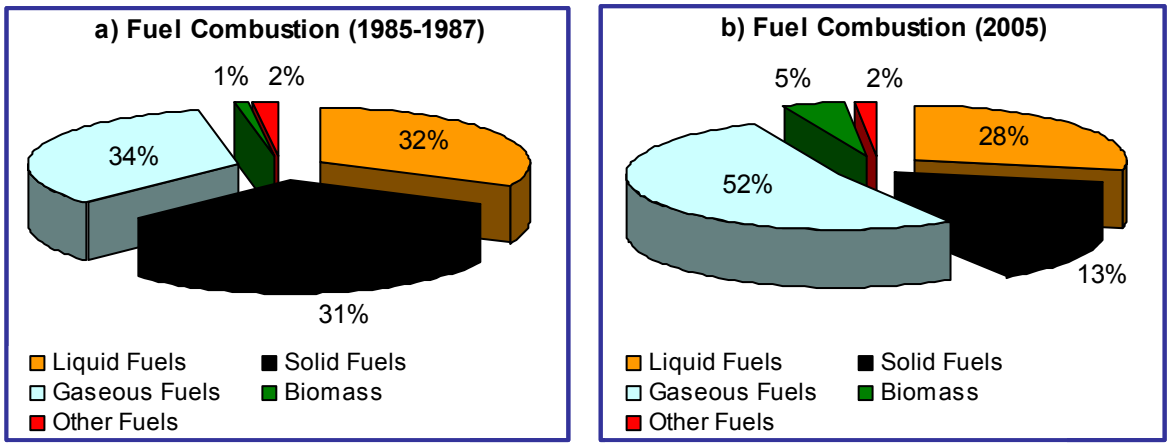

Figure 3.3. *Fuel combustion in the base year (a) and 2005 (b)*

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 72.5% (without LULUCF) to total, and 94.6% to sectoral emission (*Figure 3.4*). Within this, among fuels, gases have the highest proportion (48.2%), liquids have less, and solids have the lowest, but the latter still represents 22.6% of the sectoral CO_2 emissions. The most important subsector of the energy sector is Other Sectors (1.AA.4) with a proportion of 29.2%, followed by Energy Industries (1.AA.1), which represents 27.9% of the total emissions in this sector. This year the least contribution to the emission from fuel combustion has Manufacturing Industries and Construction Sector (1.AA.2). Fugitive Emissions from Fuels (1.B) play only a small role in emissions of the sector with 3.5%.

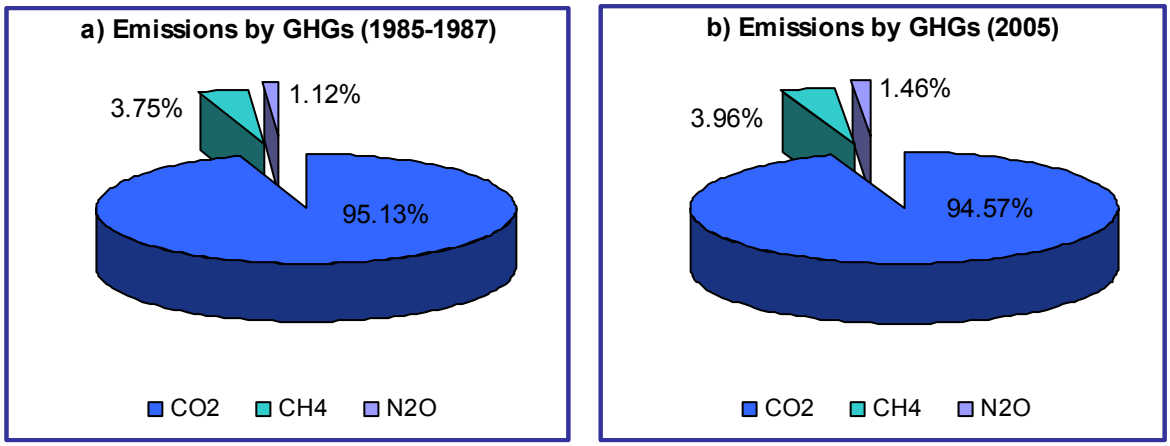

Figure 3.4. *Distribution of emission of GHGs in energy sector in the base year (a) and 2005 (b)*

As regards methane emission, this sector represents 3.2% (without LULUCF) in the total greenhouse gas emission. Primarily, this result from fugitive emissions associated with

conventional oil and gas production and processing (which also includes fugitive emissions from natural gas transmission). Among methane emitters, this sector's proportion is 31.2%, which represents the second highest emission compared to other sectors *(Figure 3.5.)*.

As regards nitrous oxide emission, this sector represents 1.2% (without LULUCF) in the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 9.27%, which represents the third highest emission compared to other sectors *(Figure 3.6)*.

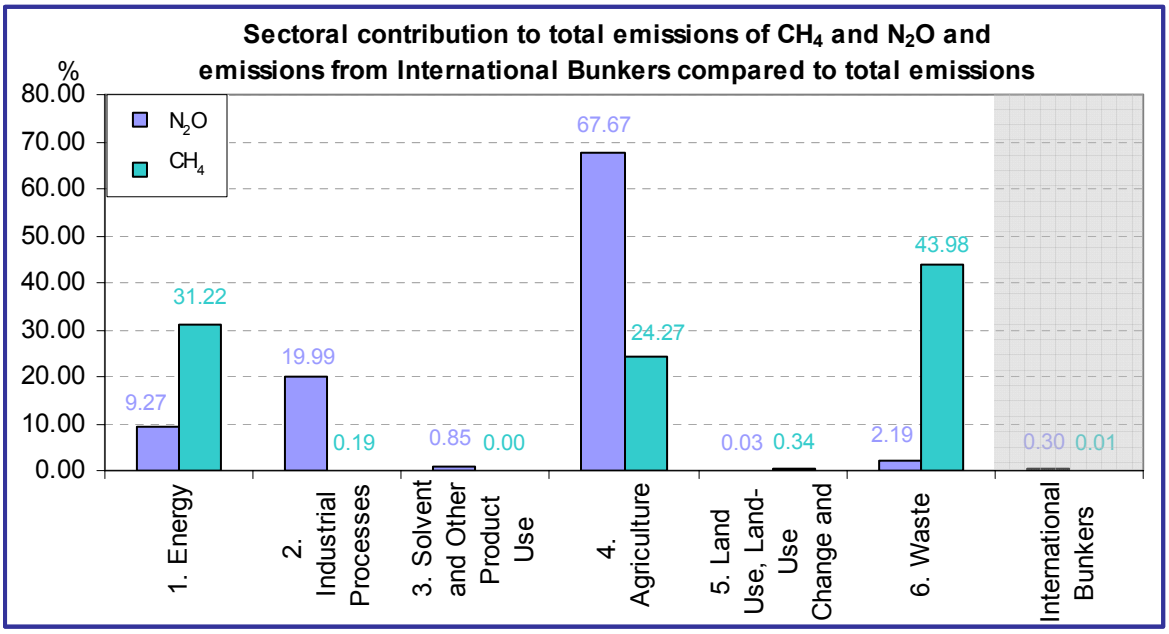

Figure 3.5. *Sectoral contribution to total emission of CH_4 and N_2O in 2005*

Figure 3.6 shows the emission tendencies in the sector by gases.

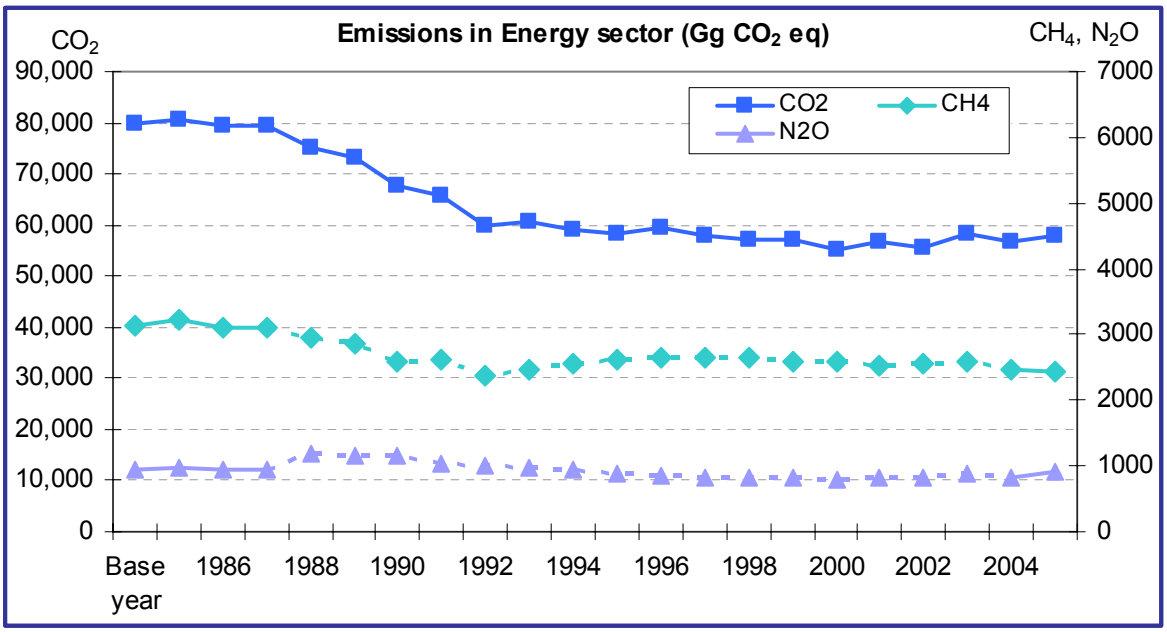

Figure 3.6. *CO_2, CH_4 and N_2O emissions in energy sector (1985-2005)*
Between 1988 and 2003 CH4 and N2O emissions from road transport are inconsistent with emissions from other years.

Calculation of the greenhouse gas emissions from combustion is based on the amount of fuel used. This was calculated using the energy balance of Hungary (summary table: see *Annex 2*), the fuel balance for each fuel type and fuel consuption for each energy sector prepared by Energia Központ Kht. (2007). Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary (KSH, 2006), discussons with the Hungarian Oil and Gas Company Plc. (MOL) and the Mining Bureau of Hungary.

The quantity of CO_2 from energy consumption was determined on national level (Reference Approach, more details in *Annex 2.4*) and on sectoral level (Sectoral Approach). Comparing the two approaches the difference was 0.46% in energy consumption and -0.08% as regards CO_2 emission in 2005. Due to the negligibility of the difference, no further corrections were necessary. Detailed discussion of this comparison is provided in *Annex 4*.

The Revised 1996 Guidelines (IPCC, 1997) were used for the determination of the non-energy uses of fuels (concerning the consumption of fuels as raw materials for the production of other products, or the use of fuels for non-energy purposes), naturally, for both approaches; and the potential CO_2 emissions therefrom were taken into account by filling the CRF tables appropriately. As a result of the inclusion of these items in the inventory, the IEF value is often significantly different from the emission factor actually applied, particularly in the chemical industry sector (1.AA.2.C), where non-energy uses are remarkable. For example, in the case of liquid fuels, the IEF is only 37.78 t CO_2/TJ (in contrast to the 70 to 75 t/TJ of other sectors), because 36 003 TJ of the 70733 TJ is used as feedstock (naphtha), and only 49.1% of this is converted to carbon dioxide.

LPG and Petroleum Coke was taken into account as liquid fuels having significant influence on the IEF value of this fuel type.

Non-energy uses have been considered in connection with sectors presented in *Table 3.1.*

Fuel type	Allocated under the sector …	IPCC code
Natural gas	Manufacturing Industries and Construction – Chemicals	1.AA.2.C
Naphtha	Manufacturing Industries and Construction – Chemicals	1.AA.2.C
Bitumen	Manufacturing Industries and Construction – Other	1.AA.2.F
Gas/Diesel Oil	Manufacturing Industries and Construction – Other	1.AA.2.F

Table 3.1. *Non-energy use of fuels in the energy sector*

The amount of fuels used is normally the same or nearly the same as the values published by IEA, because Energia Központ Kht. prepares the database for IEA, too. In case of liquid fuels, differences may be present because certain minor items in the inventory, such as white spirits, paraffins etc. are included under Other Fuels. It should be emphasised that these

poolings have no significant effects on the emission calculations.

In accordance with the Revised 1996 Guidelines, emissions from international aviation were included under the category International Bunkers on the basis of the quantities of kerosene used. The rate of the activity was taken equal to the amount of kerosene sold in Hungary – on the basis of the energy balance. In the time series of the resulting CO_2 emission, significant jumps are present at certain places, which are obviously due to the changes in kerosene consumption because the same EF was used throughout the entire time series. Naturally, changes in kerosene consumption reflect the travelling/transport needs. This is clearly illustrated in *Table 3.2*, which shows the air travelling/transport performance of the past years.

Air transport	2000	2001	2002	2003	2004	2005
Passengers carried (thousands)	2,476	2,359	2,297	2,719	3,550	5,074
Transported quantity of goods (kt)	22	24	10	13	19	16
Quantity of kerosene (TJ)	8,957	7,602	8,150	8,358	8,610	9,368

Table 3.2. *Air travelling and transport performance in Hungary since 2000 (Source: KSH, 2006; Energia Központ Kht., 2007)*

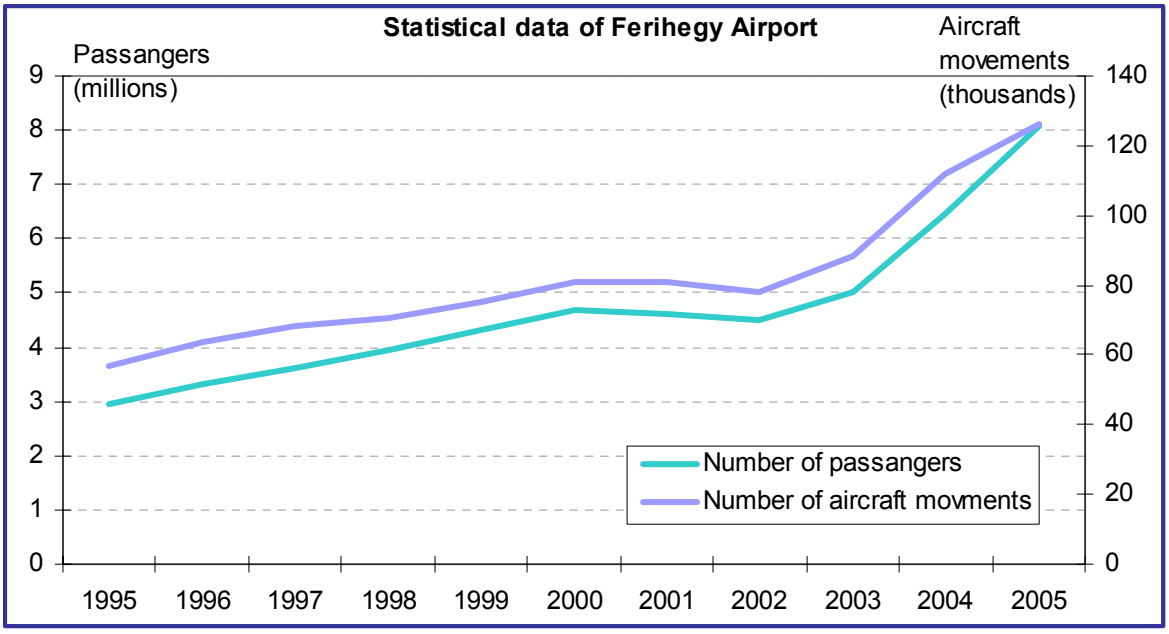

Figure 3.7. *Passangers and aircraft movements at Ferihegy Airport since 1995*

Emissions from in-country aviation, which represent a very low proportion, were taken equal to the consumption of aviation gasoline, and calculated on the basis of this – in those years when the related data were not available in the energy balance. Where this was not indicated in a separate line, consumption and emissions occur together with road traffic gasoline.

Consumption in international navigation was not considered, because separate data on the

uses for international navigation are not included in the national statistics.

International navigation depends not only on geographical and economic but on political conditions, too. International conflicts, wars have significant impact on international navigation, which could be seen in Hungary during and after the war in Yugoslavia. The war set back the navigation on the Danube South to Hungary, and decreased the trade in Hungary, too. In the last years the sea navigation (there was only tramp navigation) has relapsed due to falling into disuse of ship-fleet. This process could traced back to the absence of Hungarian harbour on seas and Danube-sea ships. Between 1990 and 2000 the role of transportation of goods on waterways decreased from 28.2% to 2.9% among goods transportation in other ways.

(Source: Központi Közlekedési Felügyelet, http://www.trafipax.hu/index.php?akt_menu=116)

3.2. Fuel Combustion, Energy Industry (CRF sector 1.AA.1)

3.2.1. Category description

Emitted gases: CO_2, CH_4, N_2O

Key source: CO_2 – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF (see “Stationary Combustion” oil, coal, gas)

N_2O – Level 1 with and without LULUCF; Level 2 without LULUCF (see “Non-CO2 Emissions from Stationary Fuel Combustion”)

This subsector includes facilities generating electricity and district heating stations. On an overall level, there are the largest users of fossil energy (25.6% in 2005).

Due to the traditions of the Hungarian statistics, emissions from petroleum refining are calculated in manufacturing industries and construction sector as part of the chemical industry (1.AA.2.C). Coke oven gas is arisen during the manufacturing of solid fuels and the consumption of this gas is taken into account in the energy industry sector, while the energy consumption of the manufacturing is calculated under manufacturing industries and construction sector as part of the iron and steel industry (1.AA.2.A).

3.2.2. Methodology

Energy consumption data were taken from the energy balance of the Energy Statistics Yearbooks (1985-2007) prepared by Energia Központ Kht. Data obtained from Energia Központ Kht. – particularly old data – were not always in compliance with the IPCC resolution. These include, for example, the approach to LPG fuel. In Hungary, this is classified into the "gas" category because it is combusted in a gaseous form and is closer to natural gas as regards composition and emission characteristics. However, IPCC classifies LPG as a liquid fuel although its emission characteristics are much more favourable than those of oils. Therefore, in terms of the specific emission factors, LPG should not be taken together with oil derivatives, otherwise it will affect the cumulative specific emission factor. It should be noted that in Hungary, the importance of LPG has been decreasing during the recent years as a result of the development of the natural gas supply network.

The Hungarian coal terminology slightly differs from that of IPCC. The partitioning is created according to the age of coal; *Table 3.3* shows the classification according to the Hungarian and IPCC categories. Energy Statistics Yearbook deals with antracite, hard coal, brown coal and lignite in the case of fuel balance, while the sectoral energy consumption for coal is the aggregate of hard coal, brown coal, lignite, gas coke and coking coal. In the latter case it is necessary to use additional information, from e.g. statistical yearbooks (KSH, 1985-2006), for the distribution of the use of each coal type.

Hungarian Terminology	Net Calorific Values	IPCC Category (Gross calorific value)
Hard Coal	17-33 MJ/kg	Other Bituminous Coal (>23.865 MJ/kg)
Hard Coal	17-33 MJ/kg	Sub-Bituminous Coal (17.435 MJ/kg -23.865 MJ/kg)
Brown Coal	10-17 MJ/kg	Lignite (<17.435 MJ/kg)
Lignite (young brown coal)	3.5-10 MJ/kg	Lignite (<17.435 MJ/kg)
Gas Coal and Coking Coal		Coking Coal

Table 3.3. *Comparison of Hungarian and IPCC coal terminology (Source: Bihari, 1998; IPCC, 2006)*

In Energy Statistics Yearbooks, the quantities of fuels are expressed as calorific values (see *Annex 2, Table A2-4*). Therefore, these were directly used for the emission calculations and the values of the conversion factors are globally 1.0 in all of the categories.

Figure 3.8. shows the changes in fuel consumption in the Energy Industries sector.

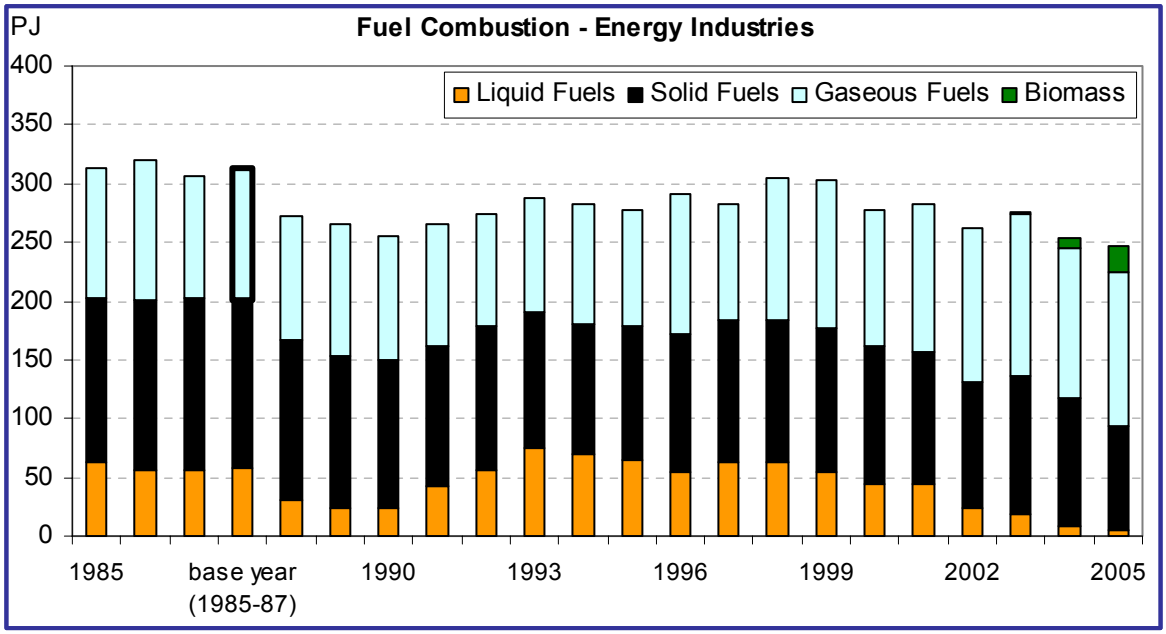

Figure 3.8. *Fuel combustion in energy industry (1985-2005)*

The total fuel consumption shows a slight decrease after the second peak in 1999, along with a strong fluctuation. Within this, the consumption of liquid and solid fuels has decreased significantly. However, the consumption of natural gas has increased to a slight extent. The biomass use due to burning and the so-called co-burning in power plants has became more and more important and exceeds in amount the liquid fuel use.

Emission factors

Carbon dioxide emissions were calculated in accordance with the Revised 1996 Guidelines in both the Reference and the Sectoral Approach. The values of the different factors were taken into consideration on the basis of the handbook, as follows: in most cases the emission factors were taken from the Revised 1996 Guidelines, as they can be found in *Table 3.4.*

Fuel type	Emission factor (CO_2 t/TJ)	Oxidation factor
Coking coal	94.6	0.98
Other Bituminous Coal	***99.0***	***0.98***
Lignite	***108.8***	***0.98***
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Crude Oil	73.34	0.99
NGL	63.07	0.99
Gasoline	69.3	0.99
Jet Kerosene	71.5	0.99
Gas/Diesel Oil	74.07	0.99
Residual Fuel Oil	77.37	0.99
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	***98.08***	***0.99***
Other Oil	73.33	0.99
Natural Gas	56.1	0.995
Biomass (Solid and Gaseous)	109.63	0.99

Table 3.4*. CO_2 emission factors used in energy industry (Source: Revised 1996 Guidelines (IPCC, 1997); in bold and italics – EU ETS database of Hungary)*

As a result of the CO_2 emission trading introduced by the EU, coal-fired power station started to measure the calorific value and the carbonate content of the fuels used in. This revealed a significant underestimation of the emission factor for lignite in the Revised 1996 Guidelines. Therefore, for this type of coal the previous value of 101.2 t/TJ was replaced by 108.8 t/TJ in 2005. It should be noted that emission factor for the Hungarian lignite is 113 t/TJ according to the EU-ETS measurements. It is very important to mention that the IPCC terminology differs from the Hungarian system (see *Table 3.3* and *Annex 4, A2.3. Source of the Country Specific Emission Factors*), and part of the Hungarian brown coal is taken into account as lignite. Therefore the emission factor for lignite is derived according to the mass proportion of lignite and brown coal, both mined in Hungary. The entire time series of emission factor were corrected using this method.

Default emission factors for methane and nitrous oxide have been used in the case of liquid fuels since this year. Country specific N_2O emission factor for solid fuels was changed to default value from 2006 IPCC Guidelines. For other fuel types the original country specific values are kept. Accordingly, different values were used for power stations and for district heating stations using smaller boilers. Thus, the following values were used for the

calculations:

Special Emission Factors (kg/TJ)	Power station		District heating station	
Fuel type	**CH_4**	**N_2O**	**CH_4**	**N_2O**
Coal	1.25	***1.50***	80.00	***1.50***
Natural Gas	0.50	3.00	5.00	2.40
Residual Fuel oil	***3.00***	***0.60***	***3.00***	***0.60***
Gas/Diesel Oil	***3.00***	***0.60***	***3.00***	***0.60***
Firewood	30.00	4.00	–	–

Table 3.5*. Special emission factors for methane and nitrous oxide in energy industry (Source: Revised 1996 Guidelines (IPCC, 1997) and expert judgement based on technology and range of the EF values in the 2006 IPCC Guidelines (Tajthy, 1994)) (Changed factors are in bold and italics.)*

In 2003, wood-firing was introduced in the energy industry. Emssion factors were taken from the Revised 1996 Guidelines (IPCC, 1997).

3.2.3. Uncertainties and time-series consistency

Practically, the accuracy and uncertainty range of the energy statistics data are determined by the accuracy of the measuring equipment (except for stock changes, which are based on expert estimates and are not comparable with the quantity of fuels from other sources). Taking all this into account, the estimated uncertainty of the energy consumption data is ±2%. This is particularly likely because the quantities of fuels used by power stations were verified using the report of MVM Rt. (Hungarian Power Companies PLC.)

The estimated specific uncertainty for CO_2 is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N_2O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

The time-series data is not consistent. Recalculations in N_2O emissions are performed only for the base years (1985, 1986, 1987), 2004 and 2005.

3.2.4. QA/QC information

As mentioned above, energy consumption data were subject of several rounds of verification before use.

3.2.5. Recalculation

In case of liquid and solid fuels, N_2O emission factors were changed to default IPCC 2006 factors, because the former country specific values seemed much higher than the default ones and the values used by neighbouring countries, (See *Table 3.5*). CH_4 emission factor for liquid fuels was also changed to default factor.

3.2.6. Planned improvements

During the QC procedures it was found that CO_2 emission factor of petroleum coke (26.75 tC/TJ) is not the default value (27.5 tC/TJ), even though it is written as default in the CRF. It is planned to change to the default factor. It will affect emissions of the last two years, only.

EU ETS will give opportunity to get detailed information from establishments that emit more than 500 kt CO_2/year. These installations can calculate their emission according to measurement data. Evaluating the measurements it is possible to define new emission factors that suit better to the Hungarian conditions. Instead of IPCC default emission factors we will calculate the national emissions using more appropriate values. Besides, we will get more detailed and technology-specific information about fuel combustion in the field of energy industry, manufacturing industry and construction.

3.3. Fuel Combustion, Manufacturing Industries and Construction (CRF sector 1.AA.2)

3.3.1. Category description

Emitted gases: CO_2, CH_4, N_2O

Key source: CO_2 – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF (see “Stationary Combustion” oil, coal, gas)

N_2O – Level 1 with and without LULUCF; Level 2 without LULUCF (see “Non-CO2 Emissions from Stationary Fuel Combustion”)

This subsector covers emissions from the combustion of fuels in the industrial sector. Owing to the traditions of the national statistics system, combustion emissions from energy conversion (coke production) and oil refining are also calculated here. Special attention was paid to avoid double accounting. In the Other subsector (1.AA.2.F) emissions from all the sectors are not included in the previous listing (A to E) are calculated.

These include:

- Mining and Quarrying
- Manufacture of electrtical and optical equipment
- Manufacture of transport equipment
- Manufacture of textiles and textile products
- Manufacture of leather and leather products
- Manufacture of wood and wood products
- Manufacturing goods not elsewhere classified
- Construction
- Communications
- Storage

As regards other fuels from which only a part is subjected to direct combustion and other parts (e.g., bitumen) are not, these were included under the line “Other Fuels” in the Other subsector (1.AA.2.F). CO_2 emissions from such fuels were taken into account in the appropriate proportions pursuant to the Revised 1996 Guidelines. For the very reason that such materials are not subjected to direct combustion, no CH_4 and N_2O emissions are calculated here.

3.3.2. Methodology

The energy consumption data were also calculated on the basis of the national energy balance prepared by Energiaközpont Kht. The calculation method and the associated problems are the same as those described under the Energy Industry (see 3.2.2).

Figure 3.9 illustrates the energy consumption of the sector. After 1990, i.e., following the economic changes, the quantities of fuels used was significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data until 2005 and presented in the Industrial Processes sector (*Chapter 4*). In 2005 the rising energy use of the industry is linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products, primarily glass and chemical industry. (Detailed description was provided in the overview on page Error! Bookmark not defined..)

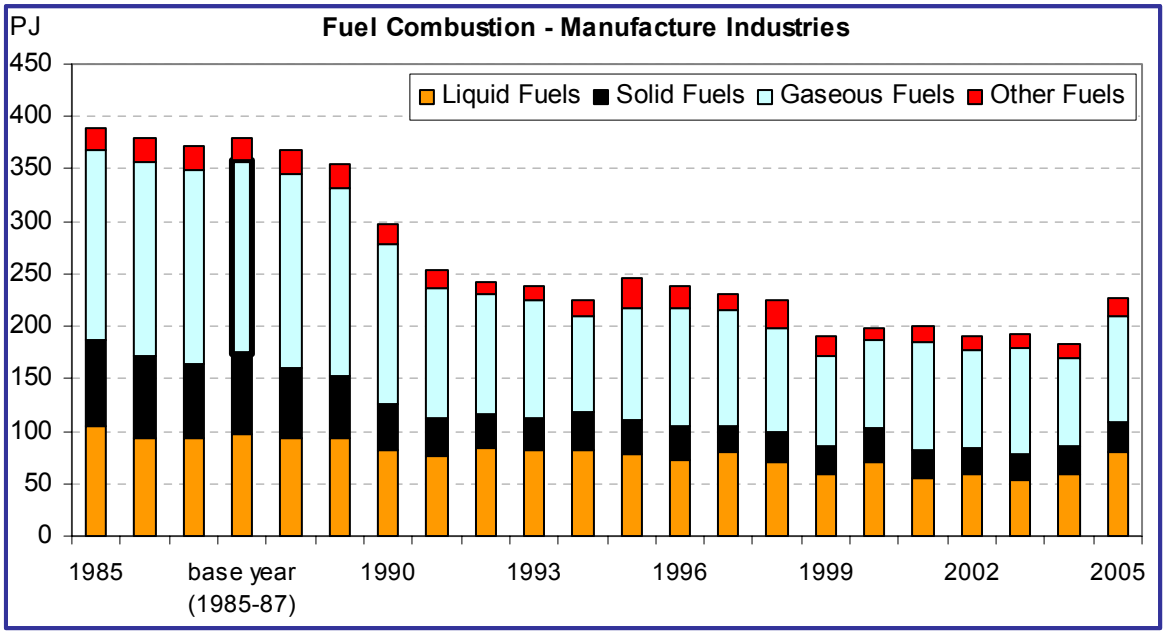

Figure 3.9. *Fuel combustion in manufacturing industry and construction*

Emission factors

The sources of the factors and the values of CO_2 factors are the same as those described under the Energy Industry (*Table 3.4*). Emission factors of gaseous fuels for manufacturing industries and construction are from CORINAIR Guidebook, 2006., max. value of Table 8.2 on page B333-8, Table 8.2 on page B332-5, Table 30. on page B115-59, Table 10. on page B112-19.

The default emission factors for methane and nitrous oxide were replaced by new values from an international literature review prepared by us before (Tajthy, 1994). Thus, the following values were used for the calculations:

Fuel type	CH_4 EF (kg/TJ)	Source of EF	N_2O EF (kg/TJ)	Source of EF
Coal	100.0	Tajthy, 1994	3.0	Tajthy, 1994
Coke	100.0	Tajthy, 1994	3.0	Tajthy, 1994
BKB	10.0	default IPCC, 1997	5.0	Tajthy, 1994
Natural gas	1.5	Tajthy, 1994	3.0	CORINAIR Guidebook, 2006
Oil – light	2.0	default IPCC, 1997	10.0	Tajthy, 1994
Oil – heavy	2.0	default IPCC, 1997	6.8	Tajthy, 1994
Oil – LPG	2.0	default IPCC, 1997	3.0	Tajthy, 1994
Wood	40.0	Tajthy, 1994	80.0	Tajthy, 1994

Table 3.6. *Country specific emission factors for CH_4 and N_2O in manufacturing industries and construction*

An explanation for the lower IEF values in the Chemicals (1.AA.2.C) is presented under *Chapter 3.1* (*Sector Overview*).

3.3.3. Uncertainties and time-series consistency

Practically, the accuracy and uncertainty range of the energy statistics data are determined by the accuracy of the measuring equipment (except for stock changes, which are based on expert estimates and are not comparable with the quantity of fuels from other sources). Taking all this into account, the estimated uncertainty of the energy consumption data is ±2% to 5% in consideration of the fact that uses are less easily traceable due to the high number of users.

The estimated specific uncertainty for CO_2 is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N_2O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

As a result of the previous recalculations, the time-series data can be considered as consistent.

3.3.4. QA/QC information

Energy consumption data were subject of several rounds of verification before use.

3.3.5. Recalculation

No changes were made to the applied methodology.

3.3.6. Planned improvements

During the QC procedures it was found that CO_2 emission factor of petroleum coke is not the default value, even though it is written as default in the CRF. It is planned to change to default factor. It will affect emissions of only the last two years.

The QC procedures pointed out that “manufacturing of non-ferrous metals” category contains “manufacturing of non-metallic mineral products”. Due to statistical traditions manufacturing of metal products includes both the ferrous and the non-ferrous metals, and emission from this category was calculated in the category “manufacturing of iron and steel”. To solve this problem we need more detailed dataset from energy statistics or EU ETS.

3.4. Fuel Combustion, Transport (CRF sector 1.AA.3)

3.4.1. Category description

Emitted gases: CO_2, CH_4, N_2O

Key source: CO_2, road transport – Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF

CO_2, other transport – Trend 1 with LULUCF and no key source without LULUCF

N_2O – Level 1, 2; Trend 2 without LULUCF and no key source with LULUCF

This sector covers all the emissions from fuels used for transportation purposes. International aviation and navigation are excluded.

During the second part of the analysed period, the composition of the national passenger car fleet underwent considerable changes. The proportion of Eastern European cars characterised by high fuel consumption decreased; currently, more than 80% of the vehicles are more advanced cars. *Table 3.7*. shows the changes in composition of the Hungarian car fleet.

Year	Proportion of the Eastern European cars
1997	56%
1998	50%
1999	45%
2000	42%
2001	39%
2002	34%
2003	30%
2004	23%
2005	16%

Table 3.7. *Proportion of the Eastern European cars in the Hungarian car fleet (Source: KTI (2006), KSH (2006))*

Elecrtification of the railways in Hungary decreased the solid fuel consumption with 99.5%. Today there are only few lines – non-scheduled -, which use steam engines.

Emissions were calculated from the national fuel consumption data. These are published in both the Energy Statistics Yearbook (1985-2007) and the publication of the Institute of Transportation Sciences (KTI, 1997-2006). For the purpose of uniformity, data from the Energy Statistics Yearbook were used, because KTI has taken into account the private imported fuels, too.

National statistics does not usually have separate lines for the quantities of aviation gasoline used for in-country aviation and of the diesel oil used for international (river) navigation (both represent negligible amounts in Hungary). Therefore, these are included under road transport.

Emissions from combustion related to natural gas transport are included under sector 1.AA.2 (Manufacturing Industries and Construction) instead of Other Transport.

Figures below illustrate fuel consumption of the sector:

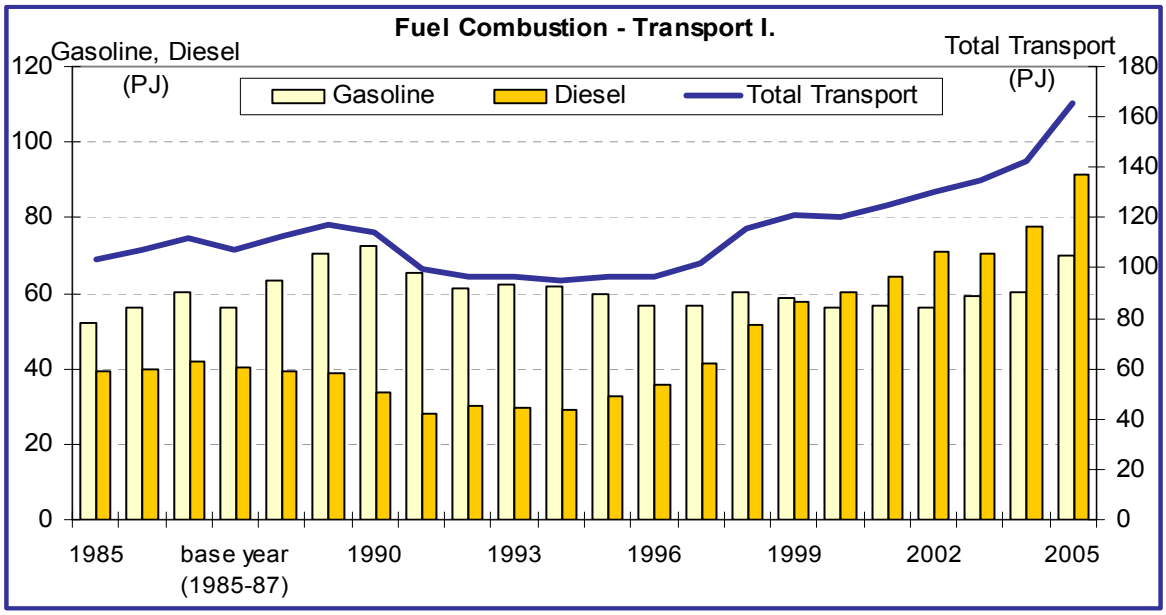

Figure 3.10. *Gasoline and diesel combustion, and total energy use in transport (1985-2005)*

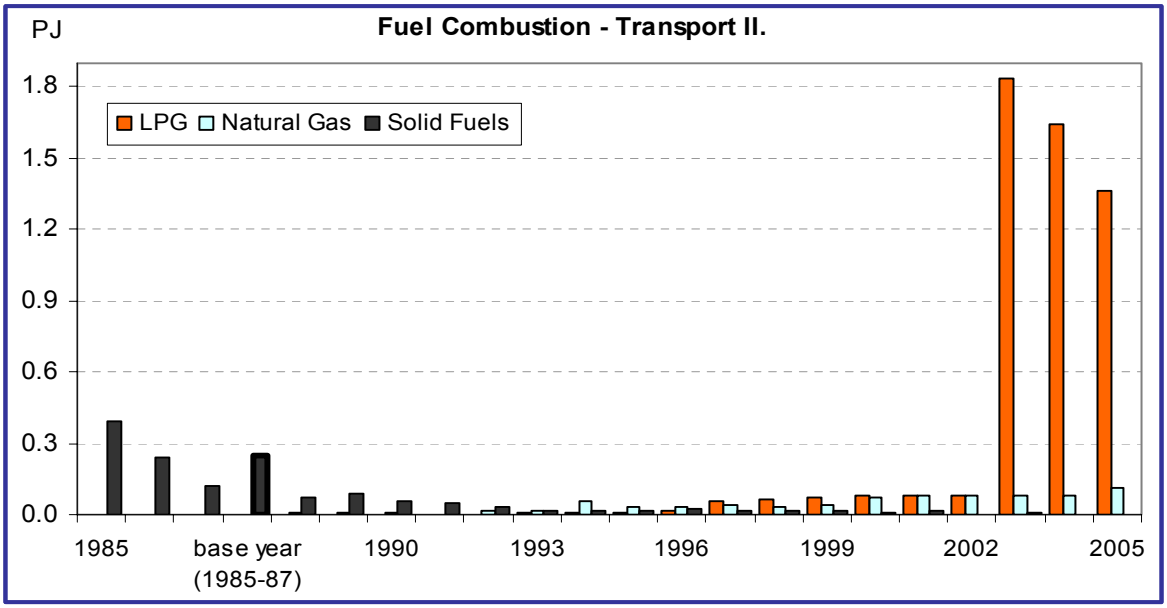

Figure 3.11. *LPG, natural gas and solid fuel combustion in transport (1985-2005)*

Figure 3.10. clearly shows that in contrast to the other described sectors, transport consumption shows a rising overall tendency.

LPG has been used since 1992. It should be noted that due to the current commercial practices, in-container (household, institutional) uses are difficult to separate from traffic uses (i.e., distribution at petrol stations). This may be the reason for the sharp increase in 2003, which does not fully reflect the actual changes but is the result of a change in the approaches used for the preparation of the inventory. Accordingly, liquid fuel uses by the general public (currently including LPG only) show a significant drop – on the basis of the national statistics (see *Chapter 3.5*).

3.4.2. Methodology

CO_2 emission from transport is calculated by multiplying fuel consumption taken from Energy Statistics Yearbooks (1985-2007) by the default IPCC emission factor (see *Table 3.4*).

Calculation of CH_4 and N_2O emissions from road transport was changed this year in conjunction with UNFCCC ERT from Tier 1 to Tier 2 as follows:

Quantification of the stock of each road vehicle type is based on Statistical yearbooks of Hungary (KSH, 1985-2006) and annual reports (KTI, 1997-2006) of the Institute of Transport Sciences.

For the base years it was assumed that passenger cars with 2-stroke engine have same sharing in traffic like other gasoline vehicles. This assumption can be applied in the early 1990s, too. For 2004 and 2005, these data were obtained from KTI reports.

It should be noted that unleaded gasoline was sold after 1989 (*Figure 3.12*). Since lead is poison for catalytic converters, catalyst vehicle has been used after this time.

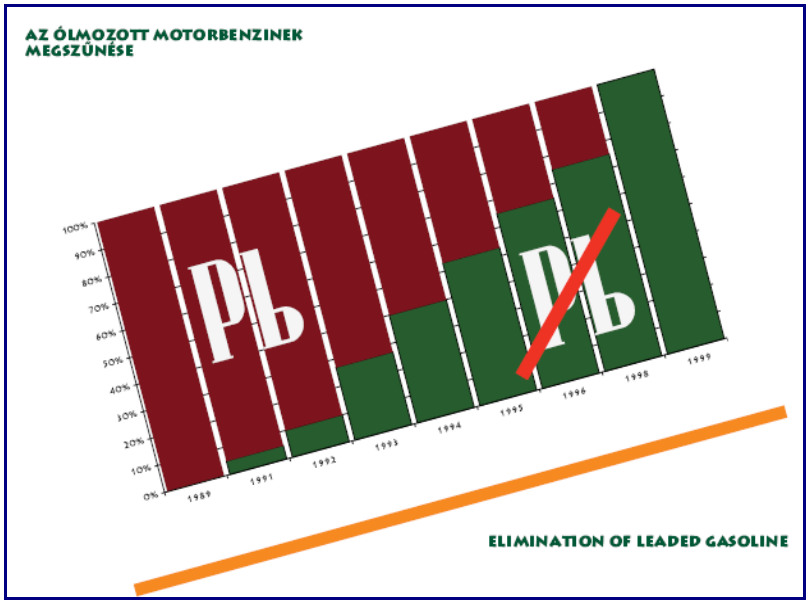

Figure 3.12. *Elimination of leaded gasoline in Hungary*
(Source: Hungarian Petroleum Association (MÁSZ), Annual Report 2005)

Emission factors in terms of g/MJ and average fuel consumption were obtained from the 2006 IPCC Guidelines, and in case of missing categories, from the 1996 IPCC Guidelines. In case of country specific information the default values were revised as follows:

- the "average passenger cars with 2-stroke engine" have an average fuel consumption of 8.4 litre/ 100 km according to official fuel consumption database (60/1992. (IV. 1.) governmental decree)
- N_2O emission of passenger cars with three-way catalyst, EURO-4 is one third of emission of the cars with early three-way catalysts (2006 IPCC Guidelines, Volume 2, p. 3.22.). Therefore, the default 18 kg/TJ was replaced with 6 kg/TJ. Use of three-way catalyst in new cars is mandatory since 2005 in Hungary. It was assumed that 20% of the new cars in 2004 were equipped with this type of catalytic converter.

Emission factors

Carbon dioxide emissions were calculated on the basis of the guidance on emissions in the Revised 1996 Guidelines (IPCC, 1997). The values of the required factors were taken into account in accordance with instructions related to fuels of the Handbook.

Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
Liquid fuels	**Gasoline**	18.9	Revised 1996 Guidelines, Table 1-2
	Gas/Diesel Oil	20.2	
	LPG	17.2	
	Residual fuel oil	21.1	
Solid fuels	**Coal - Lignite**	29.7	Country specific value, see *Annex 2.3*
Gaseous fuels	**Natural Gas**	15.3	Revised 1996 Guidelines, Table 1-2

Table 3.8. *CO_2 emission factors in transport*

Methane and nitrous oxide emission factors for road transport are summarized in the following table (*Table 3.9*).

Fuel type	Vehicle type	Emission control technology	Emission factor (kg/TJ)		Average fuel consump-tion (l/100km)	Source of EFs and average fuel consumption
			CH_4	N_2O		
Gasoline	Passenger car	Uncontrolled	33.0	3.2	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		Non-oxidation catalyst	25.0	8.0	10.0	IPCC, 2006 Guidelines, V2 Table 3.2.2
		2-stroke engine	20.0	1.0	8.4	EF: Revised 1996 Guidelines, Table 1-36; Fuel: country specific information
		Three-way catalyst	7.0	18.0	8.5	Revised 1996 Guidelines, Table 1-36
		Three-way catalyst EURO-4	1.5	6.0	8.5	Expert judgement using IPCC, 2006 Guidelines, V2 Table 3.2.3
	Motorcycles		100.0	1.5	4.0	Revised 1996 Guidelines, Table 1-42
	Light duty vehicle	Uncontrolled	20.0	1.0	13.6	Revised 1996 Guidelines, Table 1-40
		Catalyst (1997 or later)*	3.8	5.7	11.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: expert judgement
	Heavy duty vehicle	Uncontrolled	20.0	1.0	22.5	Revised 1996 Guidelines, Table 1-41
		Catalyst (1997 or later)*	3.8	5.7	22.5	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2, Fuel: Revised 1996 Guidelines, Table 1-41
	Bus		20.0	1.0	22.5	Expert judgement, assuming same performace like heavy duty vehicle
LPG	Passenger car		62.0	0.2	11.2	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-45
Natural Gas	Passenger car		92.0	3.0	9.0	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement

Fuel type	Vehicle type	Emission control technology	Emission factor (kg/TJ)		Average fuel consump-tion (l/100km)	Source of EFs and average fuel consumption
			CH_4	N_2O		
Diesel	Passenger car		2.0	4.0	7.3	Revised 1996 Guidelines, Table 1-37
	Light-duty vehicle		3.9	3.9	10.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: Revised 1996 Guidelines, Table 1-38
	Heavy-duty vehicle		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel Revised 1996 Guidelines, Table 1-39
	Bus		3.9	3.9	29.9	EF: IPCC, 2006 Guidelines, V2 Table 3.2.2; Fuel: expert judgement, assuming same performace like heavy duty v.

Table 3.9. *CH_4 and N_2O emission factors in road transport*
** It was assumed, that the technology change was slower in Hungary than in Western Europe or in the USA. IPCC, 2006 suggests the low EFs after 1995*

Methane and nitrous oxide emission factors for railways and navigation are summarized in the following table (*Table 3.10*). Emissions from in-country aviation, which represents a very low proportion, were taken equal to the consumption of aviation gasoline, and were calculated on the basis of this – in years when the related data were not available in the energy balance. Where this was not indicated in a separate line, consumption and emissions occur together with road traffic gasoline, therefore civil aviation is not included in the table.

Category	Fuel type	Emission factor (kg/TJ)	
		CH_4	N_2O
Railways	Liquid fuels	3.5	6.0
	Coal - Lignite	80.0	12.0
Navigation	Gas/Diesel Oil	5.0	5.0

Table 3.10. *CH_4 and N_2O emission factors in transport (excluding road transport)*

3.4.3. Uncertainties and time-series consistency

We assume that the uncertainty of the transport-related fuel consumption data is higher than in case of immobile equipment because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is ±5%.

The estimated uncertainty of the emission factors for CO_2 is ±5-15% for CH_4 is 50%, whereas that of N_2O is 100%. It should be noted, that in the 2006 IPCC Guidelines the uncertainty for default methane and nitrous oxide factors is much higher (200-300%).
The time-series data are not consistent. Recalculations in CH_4 and N_2O emissions are performed only for the base years (1985, 1986, 1987), 2004 and 2005.

3.4.4. QA/QC information

No sector-specific information is available.

3.4.5. Recalculations

Calculation of CH_4 and N_2O emissions from road transport was changed this year in conjunction with UNFCCC ERT from Tier 1 to Tier 2.

3.4.6. Planned improvements

To achieve the consistent time-series, recalculation of emission in the above mentioned categories will be continued.

3.5. Fuel Combustion, Other Sector (CRF sector 1.AA.4)

3.5.1. Category description

Emitted gases: CO_2, CH_4, N_2O
Key source: Level 1, 2; Trend 1, 2 (see “Stationary Combustion” oil, coal, gas)

This sector covers combustion in public institutions, by the population and in the agriculture/forestry/fishing sector.

3.5.2. Methodology

Activity data and the source of the specific emission factors for CO_2 are the same as those described in Section 3.2.2.
Figure 3.13 illustrates the fuel consumption of the sector by types.

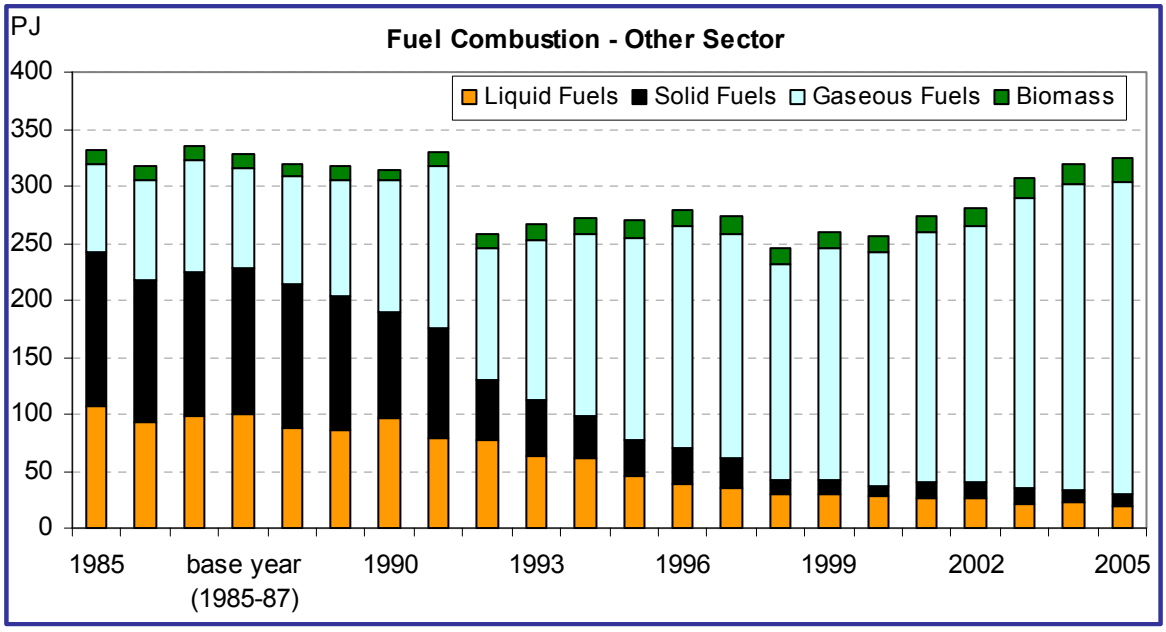

Figure 3.13. *Distribution of combusted fuels in the "other sector" (1985-2005)*

Since 59-74% of the fuel consumption is related to the residental sector, the fuel structure is influenced principally by the changes in this sector. In parallel with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. During the period 1985-2005 natural gas pipeline length has doubled (see *Table 3.18*), and the number of households supplied with natural gas has been increasing continuously. Population swithed from coal to natural gas combustion. At the same time, household heating oil was completely replaced by LPG during the last years of the analysed period, as shown in *Table 3.11*.

Sector	Fuel consumption (TJ)	1998	1999	2000	2001	2002	2003	2004	2005
Commercial/ Institutional	Oil	965	899	1,127	1,055	580	366	744	289
	LPG	1,990	2,159	2,131	1,761	1,931	1,739	1,643	1,609
Residential	Oil	250	242	54	0	0	0	0	0
	LPG	12,480	11,951	12,091	10,483	10,659	9,353	8,836	6,688

Table 3.11. *Oil and LPG consumption in the institutional and residential sector (1998-2005)*

The consumption rates of the subsectors are shown in *Figure 3.14*.

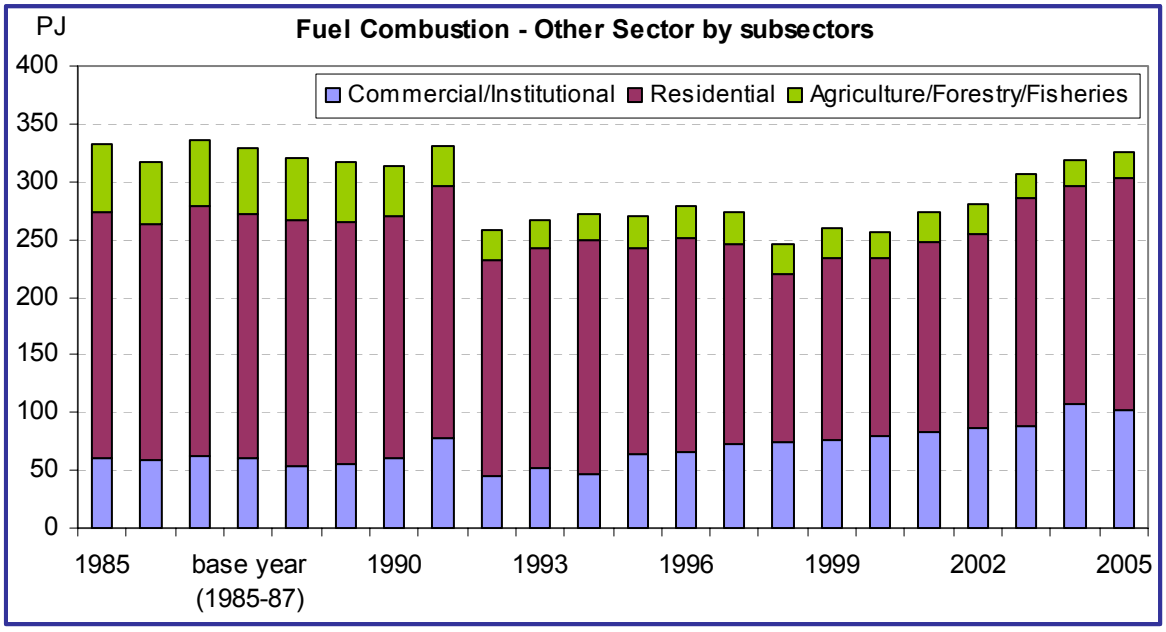

Figure 3.14. *Fuel combustion in the subsector of "other sector" (1985-2005)*

Emission factors

Since the entire quantity of liquid fuels used in residential combustion is LPG and the majority of institutional uses is also based on LPG, the IEF factor for CO_2 is very low. (The values are the same as those listed in *Table 3.4*)

Specific emission factors for CH_4 are shown in *Table 3.12*

Emission Factors for CH_4 (kg/TJ)	Solid	Natural Gas	Diesel	LPG	Residual Fuel Oil	Wood
Commercial/Institutional	90.5	5.0	5.0	5.0	5.0	100.0
Residential	96.5	5.0	5.0	1.6	1.6	470.0
Agriculture	73.3	5.0	5.0	5.0	5.0	80.0

Table 3.12. *Specific emission factors for CH_4 in the "other sector"*

Due to the relatively high briquette consumption in the agriculture, the used average factor for solid fuels is lower than in the other sectors.

Country specific N_2O emission factors were replaced by IPCC 2006 default values in gaseous fuels in the residential sector and liquid and gaseous fuels in the "Agriculture/forestry/fisheries" sector and solid fuels in general. Specific emission factors for N_2O are shown in *Table 3.13*

Emission Factors for N_2O (kg/TJ)	Solid	Natural Gas	Diesel	LPG	Residual Fuel Oil	Wood
Commercial/Institutional	***1.5***	2.5	10.0	2.0	2.0	4.3
Residential	***1.5***	***0.1***	10.0	2.0	2.0	4.3
Agriculture	***1.5***	***0.1***	***0.6***	***0.1***	***0.6***	4.3

Table 3.13. *Specific emission factors for N_2O in the "other sector" (Changed factors are in bold and italics.)*

3.5.3. HDD and energy demand of residential sector

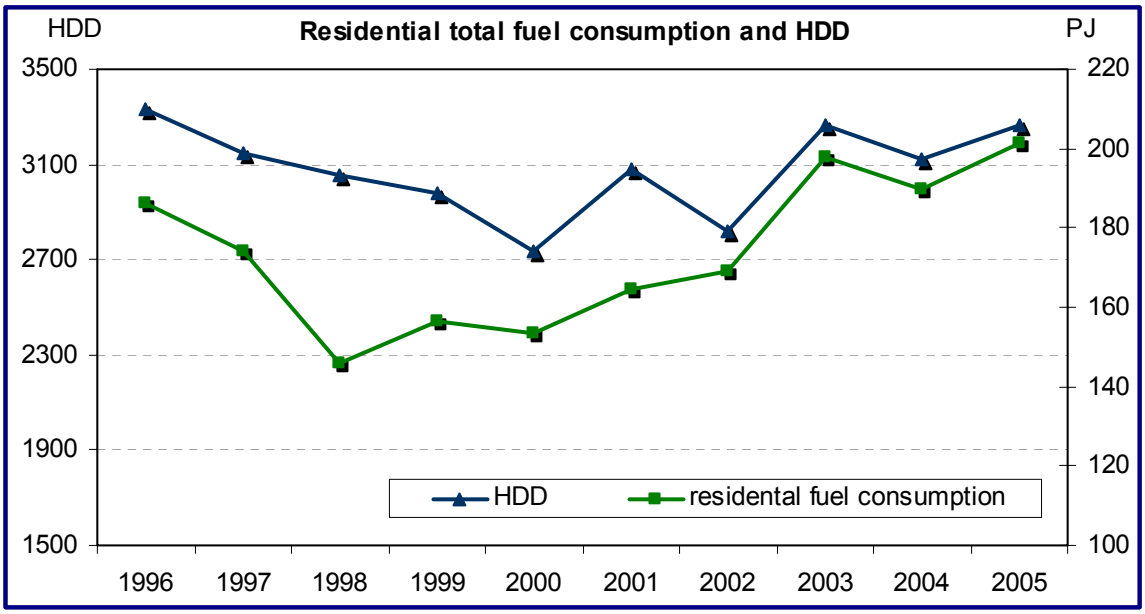

Figure 3.15. *Comparison of residential fuel consumption and HDD between 1996 and 2005*

Heating degree day (HDD) is a quantitative index demonstrated to reflect demand for energy to heat houses and businesses. This index is derived from daily temperature observations. *Figure 3.15* illustrates the relationship between residential fuel consumption and HDD. Except 1998 the two lines are running parallel.

3.5.4. Uncertainties and time-series consistency

We assume that the uncertainty of the fuel consumption data of the Other sector is higher than in case of industrial equipment because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is less than ±10%. The estimated uncertainty of the emission factors for CH_4 is moderate (±30% to 35%), whereas that of N_2O may be very high, i.e., 50% to 100%, as mentioned above.

The time-series are not consistent, CH_4 and N_2O emissions are not recalculated between 1988 and 2003 in case of gasoline and diesel in road transport sector.

3.5.5. QA/QC information

No sector-specific information is available.

3.5.6. Recalculation

In case of gaseous fuels in the residential sector and liquid and gaseous fuels in the "Agriculture/forestry/fisheries" sector and solid fuels in general, the N_2O emission factors were changed to default IPCC factors on recommendation by ERT, because the former country specific values seemed much higher than the default and the values used by neighbouring countries.

3.5.7. Planned improvements

To achieve the consistent time-series, recalculation of emission in the above mentioned sectors and fuel types will be continued.

It is planned to harmonize the country specific values with IPCC default emission factors in each category, GHG and fuel type, and to change the activity data for those prepared for IEA by Energia Központ Kht.

3.6. Other (CRF sector 1.AA.5)

3.6.1. Category description

This category contained the emissions from thermal and other deep water drills in the previous submissions. Due to the ERT suggestion it has been relocated to the fugitive emission category (CRF 1.B.2.D).

3.7. Fugitive Emissions from Fuel (CRF sector 1.B)

3.7.1. *Category* description

Emitted gas: CO_2, CH_4

Key source: CH_4 – Trend 1 with and without LULUCF ("Fugitive Emissions from Coal Mining and Handling")

Level 1, Trend 1 with and without LULUCF; Level 2, Trend 2 without LULUCF ("Fugitive Emissions from Oil and Gas Operations /main source: gas distribution/")

This category includes fugitive CO_2 and CH_4 emissions released during coal mining and handling and oil and natural gas activities. Emissions from fuels used during these activities are calculated under sector 1.AA.2 (Manufacturing Industries and Constructions).

In Hungary, both underground and surface coal mines are present. Although underground mining was the predominant form in the 1960's and 1970's, it represents only 17% today. Underground mining continues to decrease in both relative and absolute terms.

In the past, oil production and processing was an important sector in Hungary, but production's importance is decreasing as the reserves are running out. Gas mining shows similar tendencies, although the reduction is less intensive. At the same time, natural gas uses show a significant increase as a result of the sharply growing import, as previously described.

3.7.2. Coal mining

Methodology

Emission calculations are based on detailed activity data. The actual quantities released into the atmosphere are obtained by multiplying the data by the specific emission factors.

In Hungary, both underground and surface coal mines are present. Although underground mining was the predominant form in the 1960's and 1970's, it represents only 15% today. Drastic reduction in coal production was observed between 1987 and 1988, as well as between 1989 and 1990. Underground mining continues to decrease in both relative and absolute terms, therefore distribution of mined coal types underwent significant changes (*Figure 3.16*).

Year	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	
Coal production (10^6 t)	24.04	23.13	22.84	20.88	20.03	17.66	17.06	15.75	14.61	14.11	
Year	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Coal production (10^6 t)	14.59	15.19	15.59	14.65	14.55	14.03	13.91	13.03	13.30	11.24	9.57

Table 3.14. *Coal production time series in Hungary*

Production data were taken from the KSH and Energy Statistics Yearbooks. These statistical yearbooks provide the production of surface and underground mines for each coal type.

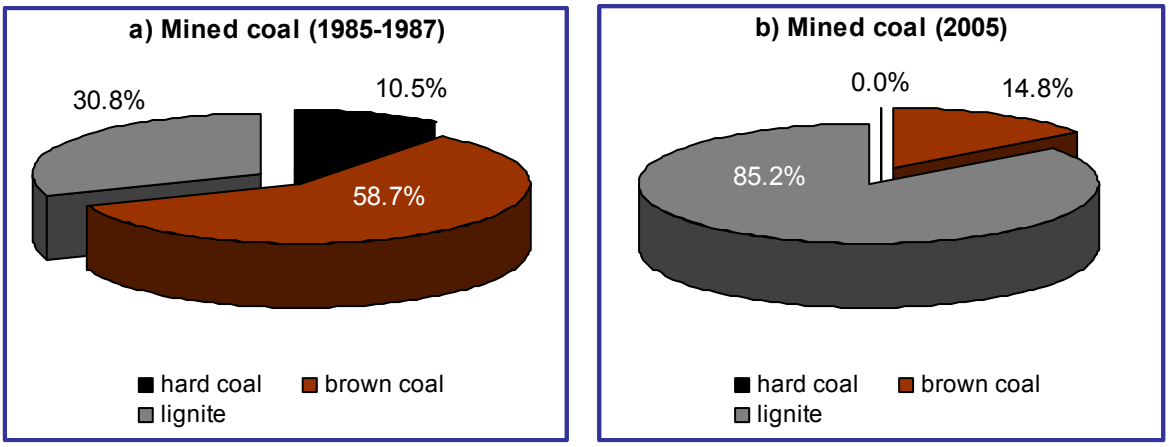

Figure 3.16. *Distribution of mined coal in the base year (a) and 2005 (b)*

Hungarian mines are not drained. There is no mine-burning or burning coal waste piles. From the older coal waste piles the combustable part has been extracted with Haldex technology for decades. Abandoned mines are gobbed and are flooded with water – informed by the Mining Property Utilization Company in the Public Intrest –, therefore methane emission can be negligable.

Emission factors

Emission factors were taken into consideration according to the information from Mining Bureau of Hungary and measurment data from mines. Emissions were calculated for the following categories: hard coal, brown coal and lignite (*Table 3.3*).

Both mining types occurred in hard and brown coal mining, but there is only limited information about the production, therefore the total amount of hard coal and brown coal was taken into account as underground mining.

Coal type	Mine	In-situ CH_4 content (m3/t)
Hard coal	Pécsbánya – Karolina	18.26
	Vasas – Észak	20.75
Brown coal	Balinka	1.29
	Lencsehegy	0.00
	Mány I/a	0.98
	Márkushegy	0.93
Lignite	Bükkábrány	0.00
	Visonta	0.00

Table 3.15. *In-situ CH_4 content in Hungarian mines*
(Source: REKK, 2004 (original data: Hungarian Geological Survey, disclosure of mines))

Table 3.15 shows the measured methane content of coal for in the last few years active mines in Hungary. Mine of Lencsehegy closed in 2004, previously it had been producing significant amount of coal having 0.0 m^3/t methane. In 2005 the only one operating mine was Márkushegy with 0.93 m^3/t in-situ methane content. Lignite is mined only in surface mines; based on measurement data methane is not emitted during mining activity, since the Hungarian lignite is relatively young in the coalification (NCV is under 10 MJ/kg).

Emission factors for coal mining and post-mining are summarized in the following table (*Table 3.16*). For mining activities emission factors were derived from measurement data, in case of post-mining according to the IPCC 2000 Guidance, emission factor was calculated as 10% of mining value. The new emission factors are lower than the default or perviously used values.

Coal mining		**Emission factor (kg CH_4/t)**	
		Default	**Hungarian**
Underground mining	Hard coal	6.700-16.750	13.065
	Brown coal		0.670
Post-mining	Hard coal	0.603-2.680	1.340
	Brown coal		0.067
Surface mining	Lignite	0.201-1.340	0.000
Post-mining		0.000-0.134	0.000

Table 3.16. *Comparison of IPCC default and country specific emission factors for coal mining*

3.7.3. Oil and gas activities

Methodology and emission factors

Activity and consumption data related to extraction and primary handling were taken from Energy Statistics Yearbook. In addition, data from the KSH and from production companies were used.

In the past, emissions were calculated using the specific emission factors provided for *Eastern European technologies* in the Revised 1996 Guidelines. In response to the comments of the ERT and also due to the ambiguous relationship between activities and specific emission factors, we contacted the production companies and the emission calculations were adjusted in cooperation with them, on the basis of the new information obtained. Such fundamental changes were required because the technologies used in Hungary are entirely based on “Western” equipment; therefore, the use of the specific

emission factors for Eastern Europe, which are high and associated with great uncertainty, is not justifiable. Since we do not have own measurements, it was decided – on the basis of the data available from the production companies – that the Canadian calculation presented in the Background Papers published by IPCC (2002) would be used. Hungarian data for the activities indicated in this calculation were determined and multiplied by the provided specific emission factors.

The included technologies and the applied specific emission factors are as follows:

Oli and Gas Activities (unit)	CH_4 emission factors (Gg/unit)
Wells – Drilling (number)	$4.3 \cdot 10^{-7}$
Wells – Testing (number)	$2.7 \cdot 10^{-4}$
Wells – Servicing, (number)	$6.4 \cdot 10^{-5}$
Gas Production ($10^6 m^3$)	$3.1 \cdot 10^{-3}$
Gas Processing – Sweet Gas Plants ($10^6 m^3$)	$7.1 \cdot 10^{-4}$
Gas Processing – Sour Gas Plants ($10^6 m^3$)	$2.4 \cdot 10^{-4}$
Gas Processing – Deep-cut Extraction Plants ($10^6 m^3$)	$7.2 \cdot 10^{-5}$
Gas Transmission (km)	$3.4 \cdot 10^{-3}$
Gas Storage ($10^6 m^3$)	$8.4 \cdot 10^{-4}$
Gas Distribution (km)	$5.2 \cdot 10^{-7}$
NGL Transport – Condensates and Pentanes Plus ($10^6 m^3$)	$1.1 \cdot 10^{-4}$
Oil Production – Conventional ($10^6 m^3$)	$1.8 \cdot 10^{-3}$
Oil Transport – Pipelines ($10^6 m^3$)	$5.4 \cdot 10^{-6}$
Oil Transport – Tanker Trucks and Rail Cars ($10^6 m^3$)	$2.5 \cdot 10^{-5}$

Table 3.17*. Source-specific emission factors in oil and gas activities (Source: IPCC - Background Papers, 2002)*

In addition, trial calculations were made using the specific emission factors for "Western" technologies from the Revised 1996 Guidelines. The results were in the same order of magnitude as before. Energy Statistic Yearbook contains a special category, the network loss, which is a statistical concept. The real fugitive emission is about one third of the network loss in natural gas distribution. The results of the above mentioned methodology and emission factor are in good agreement with the statistical value.

Gas transport represents the highest proportion in the emissions. In Hungary, gas supply, as well as the total length of pipelines, has been growing significantly over the past 20 years. Annual data for pipeline lengths are indicated in *Table 3.18.*

Flaring was estimated – due to lack of information about emission – on the basis of detailed production data obtained from oil and gas companies and using default emission factors of the 2006 Guidelines (IPCC, 2006).

Pipeline length (km)							
Year	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Transmission	3,345	3,683	3,786	3,910	4,035	4,170	4,046
Distribution	10,262	12,474	14,200	18,380	18,380	22,559	25,306
Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Transmission	4,468	4,684	4,907	4,957	5,069	5,118	5,167
Distribution	45,113	53,436	58,074	63,585	67,161	70,589	72,540
Year	**1992**	**1993**	**2001**	**2002**	**2003**	**2004**	**2005**
Transmission	4,188	4,368	5,214	5,214	5,214	5,234	5,234
Distribution	29,611	37,568	74,559	75,836	78,018	79,377	80,519

Table 3.18. *Annual data for natural gas pipeline lengths (1985-2005)*

3.7.4. CH_4 emission from thermal water

This category, which was allocated under 1.AA.5.A (Other stationary fuel combustion) in the previous submissions, contains the emissions from thermal and other deep water drills.

In Hungary, and especially in the Great Plain, subsurface waters and deep wells drilled for various purposes contain varying quantities of methane. Upon the abstraction of such waters (as drinking and/or as thermal water), methane is also abstracted and released into the atmosphere. According to a previous expert estimate, the annual quantity of methane released from wells is approx. 20 Gg. We believe that this item should also be included in the methane emissions for the sake of completeness. However, it does not have an appropriate “slot” in the inventory. Thus, such emissions were included in the Other sector (Geothermal, Other Fuels) in the following way: the emissions are indicated in the CH_4 column but the box for Activity Data was left empty because emissions are not related to fuel consumption.

It is planned that these emissions will be analysed in more details. So far, the capacities have been insufficient for the collection and evaluation (including retrospective collection and evaluation) of potentially available data from some ten thousands of wells.

3.7.5. Uncertainties and time-series consistency

The uncertainty of the majority of the activity data from recent years is favourable. These include main production data and pipeline lengths. The uncertainty of other values and specific emission factors is moderate; however, in the lack of other information, this cannot be quantified, only estimated. Naturally, the uncertainty of older data is higher due to the incomplete availability of the required information.

As a result of the accomplished concordant calculations, time-series data can be considered consistent.

3.7.6. QA/QC information

No sector-specific information is available.

3.7.7. Recalculation

Fugitive emissions from coal mining were recalculated using newly provided domestic data. From year to year changing proportion of coal types in extraction was also taken into account. According to this the emission decreased as follows:

Year of submission	Emission in base year (Gg CH_4)	Emission in 2004 (Gg CH_4)
2006	72.76	13.41
2007	45.26	5.58

Table 3.19. *Impact of recalculation of fugitive emission of coal mining*

In underground hard coal mines some part of developed methane was utilized until 1996. This, and the CO_2 emission of it is presented in the database between 1985-1996.

According to the ERT suggestions the applied contractions (natural gas transmission and distribution) were dissolved and rows of activity data were filled properly. In accordance with this fugitive emission from underground storage of natural gas is presented in 1.B.2.D. Other sector under “Underground storage”. Due to the ERT suggestion, fugitive emission from thermal water has been relocated from Other category in 1.AA.5. to this Other category (CRF 1.B.2.D.), too.

Calculation in fugitive emissions was extended with flaring in submission 2007. This results emission surplus of 195.7 Gg CO_2 in the base year, which decreased to 84.9 Gg CO_2 in 2005 (due to the reduction of production).

Other recalculations were not made in sector oil and gas, only the replacing and redistribution resulted some differences in previous values. Some production data in the time-series were gap filled using interpolation.

3.7.8. Planned improvements

We will do more accurate calculations in some categories using data from EU ETS.

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4. INDUSTRY (CRF sector 2.)

4.1. Overview of the sector

This sector includes emissions generated by non-firing processes related to industrial production. The major processes include cement, iron/steel, aluminium, ammonia and nitric acid production. In addition, technologies involving fluoride gases are considered here. The emission of Industry is the third following the Energy and Agriculture sectors. (See the *Figure 2.6* in Trends of GHG Emission Chapter). The *Figure 4.1* below shows the emissions of the sector by gases:

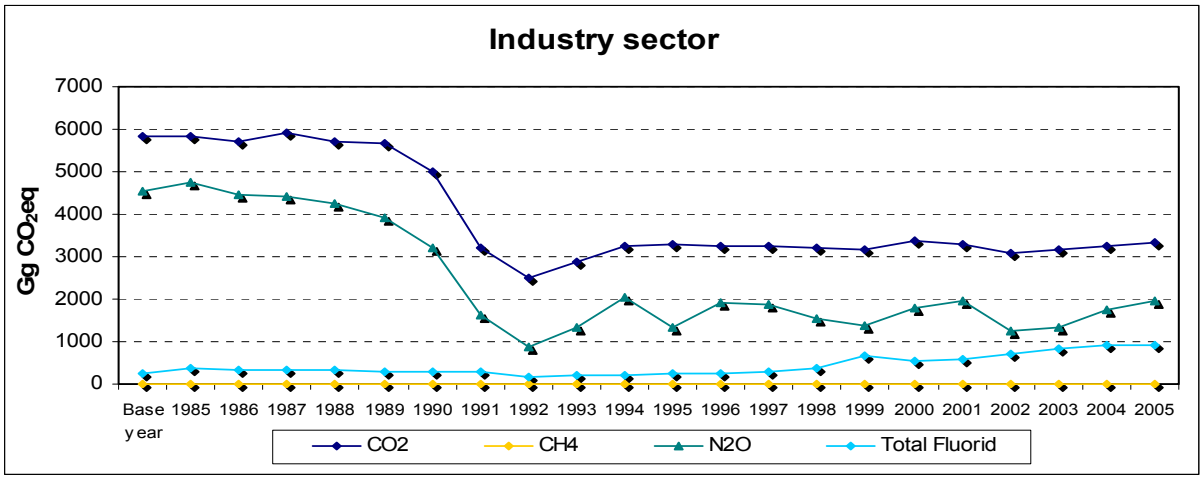

Figure 4.1. *The most significant industrial gases. In comparison with them, the quantity of fluoride gases and methane is negligible. Note: BY=average of 1985-87 but 1995 for F-gases*

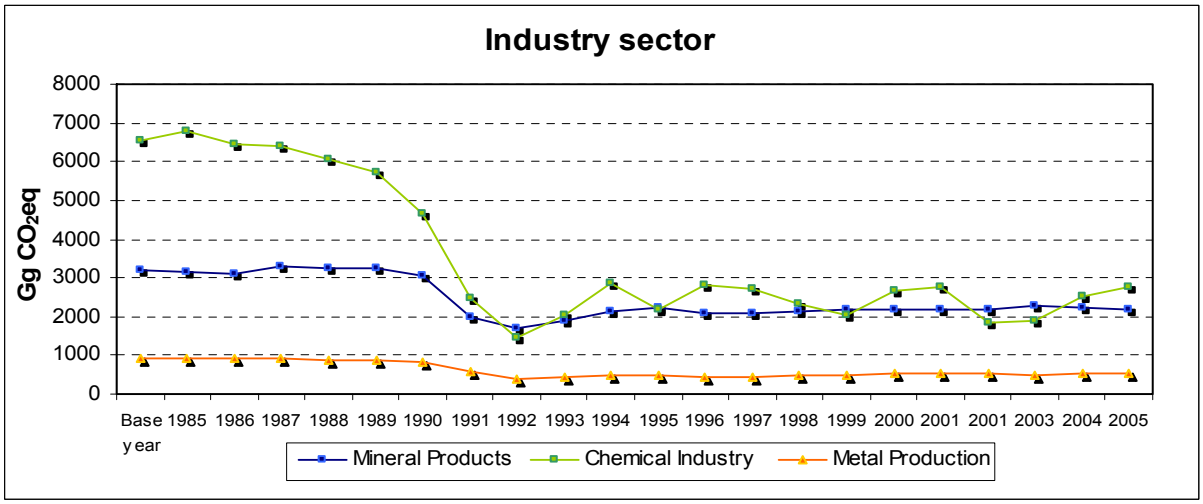

Figure. 4.2. *The emission in Industry. Note: BY=average of 1985-87 but 1995 for F-gases.*

The most important emitter is chemical industry, especially the N_2O emission of nitric acid production (see there).

The significant decrease of emission in the period between 1988-1993 is strongly represented in each of the above figures. Its reason is the economic in transition mentioned already in the previous chapters. Due partly to closing down factories and to the reduction of capacity utilization, in the course of transition, the production decreased more or less drastically in each industrial sector. Some examples:

- Cement production: two plants were closed;
- Iron and steel production: two of the three plants were provisionally closed down;
- Aluminium: two of the three plants were closed down(1991);
- Ferroalloys: ceased to exist (1991);
- Ammonia: four of the five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three of the four plants were closed down (1989, 1992 and 1996). One of the reasons of temporary production decrease was that the modernization of the remaining factories was carried out that time and in the subsequent period, entailing favourable changes of specific emission factors as well. This was the situation e.g. in the cement and limestone industry. However, in some cases the plants having more advantageous emission factors in the aspect of environmental protection have been closed, causing unfavourable changes in the national emission factor. This was the situation e.g. in the production of nitric acid.

Since the mid 1990s, the emission by industry has been showing a slowly increasing but unbalanced trend reflecting the actual demands of production in the national economy.

An example is the (relatively) significant increase of methane in *Figure 1.3*, which can be definitely connected to the increase of production in the chemical industry (see e.g. ethylene production: 2004: 374 kt, 2005: 594 kt). The increase of industrial fuel consumption in the energy sector in 2005 can be attributed to the same reason.

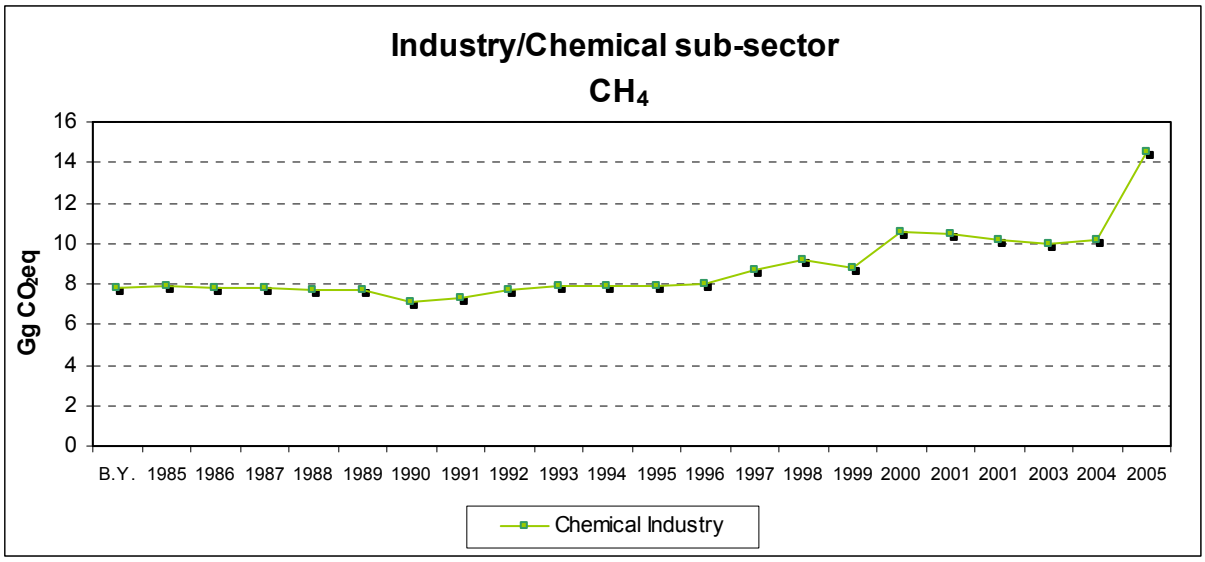

Figure 4.3. *Chemical sub-sector, CH_4 emission (Gg, CO_{2eq}).*

4.2. Mineral Products (CRF sector 2.A)

4.2.1. Cement production (CRF sector 2.A.1)

Technology

Emitted gas: CO_2

Key source: Level 1

During cement production, CO_2 is generated in the clinker production phase:

- on the one hand, during the combustion of the fuels used,
- on the other hand, during the degradation of the limestone ($CaCO_3$) fed into the furnace, which occurs at around 1,300ºC and results in CaO and CO_2 (calcinations).

The raw materials may contain other carbonate minerals (e.g., $MgCO_3$). Both dry and wet technologies may be used for the preparation of the raw clinker. Wet technology is used by one of the four cement production plants in Hungary.

Methodology

In this category, we only determined emissions from the production processes. Gases originating from fuels are included in sub-sector 1.A.2.B

As regards CO_2 generated during cement production, no direct measured data are available. Therefore, emissions of the initial years were determined on the basis of the data provided by the Central Statistical Office (KSH) and using the factors recommended by IPCC. In order

to increase the accuracy of the inventories, we contacted the affected industrial sites and obtained the necessary data directly. Thus, the calculation is in accordance with the Tier 3 method recommended by the Good Practice.

Activity data

Production data for the whole time series were obtained directly from the factories. In 2000, production at one site was abandoned. Previous production data for this factory was obtained from the Cement Industry Association. Instead of cement or clinker production, raw flour consumption was used as the basis for calculating the emissions. This is more accurate because cement factories measure the amount and composition of the raw flour. No clinker export or import occurred. The table below shows the time-series production data for 1985 through 2005.

	Base year	***1985***	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***
Clinker, kt	3,173.2	3,097.9	3,069.5	3,352.1	3,245.5	3,242.7	3,210.4	1,987.6	1,598.3	1,905.7	2,154.0
Cement, kt	3,888.9	3,670.4	3,845.2	4,150.8	3,871.4	3,856.8	3,932.8	2,563.2	2,245.6	2,521.3	2,795.3
	1995	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***
Clinker, kt	2,233.1	2,079.0	2,193.8	2,261.1	2,270.6	2,532.4	2,522.0	2,687.1	2,694.5	2,494.8	2,352.6
Cement, kt	2,874.9	2,745.0	2,806.2	2,995.1	2,979.1	3,348.2	3,452.4	3,504.2	3,564.9	3,266.7	3,363.5

Table 4.1. *Clinker and cement production in Hungary*

Emission factors

Upon receiving information on the carbonate content of the raw flour from the producers and from the Association, the quantity of CO_2 was calculated using the following formula and the proper stoichiometric proportions:

$M_{CO2}=M*C*S$

Wherein M_{CO2} means the amount of carbon dioxide generated (t/year);
M means the amount of raw flour fed into the furnace (t/year);
C means the ratio of calcium carbonate in the raw flour; and
S means the stoichiometric ratio of CO_2 and $CaCO_3$ (44.01/100.1).

On a similar way we calculated also the amount of CO_2 generated from $MgCO_3$ using the corresponding stoichiometric ratio. The results were only corrected for cement kiln dust (CKD) in the case of wet technology, because information on amount and carbonate content of dust released through the stack and separated by the separators were all provided by the operator. In the plants using dry technologies, the entire quantity of stack dust is recirculated

into the furnace.

Accordingly, average emission factors were obtained using CO_2 emissions calculated for the individual factories and production data. These are shown in the table below. In addition, the table demonstrates the time series of the annual emissions[1]:

	Base year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
$tCO_2/tclinker$	0.5596	0.5614	0.5595	0.5578	0.5608	0.5565	0.5230	0.5189	0.5396	0.5384	0.5367
$tCO_2/tcement$	0.4570	0.4738	0.4466	0.4505	0.4701	0.4679	0.4269	0.4023	0.3841	0.4069	0.4136
Total CO_2 (kt)	1,776	1,739	1,717	1,87	1,82	1,805	1,679	1,031	863	1,026	1,156
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
$tCO_2/tclinker$	0.5363	0.5483	0.5489	0.5336	0.5452	0.5501	0.5581	0.5513	0.5472	0.5374	0.5095
$tCO_2/tcement$	0.4166	0.4152	0.4291	0.4028	0.4155	0.4161	0.4077	0.4227	0.4136	0.4104	0.3564
Total CO_2 (kt)	1,198	1,14	1,204	1,206	1,238	1,393	1,408	1,481	1,474	1,341	1,199

Table 4.2. *Specific emission factors of clinker and cement and total CO_2 emission in 2.A.1 sub-sector (1985-2005).*

The default factor is 0.5071 t/t for clinker (with a CaO content of 65%), and 0.4985 for cements (Revised Guidelines). On the one hand, the table demonstrates that the rising tendency of the recent years slowed down in 2004. On the other hand, it shows that the amount of additives used in cements produced in Hungary is high and increasing. The higher specific CO_2 emission of clinker is due to the higher $CaCO_3$ content of raw flour. $CaCO_3$ content of raw flour which results in better clinker quality. This enables the higher content of additives in cement. Due to the CO_2 generated from $MgCO_3$, calculated now for the first time for the whole time series, the earlier specific factors increased by nearly 5%.

According to the emission trade system introduced by the European Union from 2005 on, the factories report their CO_2 emission. This value is calculated on the basis of the derivatograph determination of carbonate, which contains also CO_2 generated from the $MgCO_3$ content of limestone. All these increase the accuracy of emission-determination. The quantity of CO_2 emitted in 2005 is based on reports of the factories.

[1]The national total emission was calculated by summing the emissions of individual factories instead of using the average of the specific emissions.

Uncertainties and time-series consistency

Based on the information obtained from factories, the following uncertainties are associated with the data:

Uncertainty of raw material use data:	0.2 % to 1 %
Uncertainty of the carbonate content of raw material:	0.2 % to 4 %
Estimated total:	**2.1%**

On the basis of the information in the Good Practice, the following uncertainties are associated with the calculation of the emissions of cement production processes:

Production data:	1 % to 2 %
Total carbonate content of the raw flour:	1 % to 3 %
Amount and composition of stack dust (CKD):	5 %
Estimated total[2]:	**2.5 %**

The originally small uncertainty was further improved by using data of emission-trade.

By using the same calculation method for each year and data obtained directly from the operators, the consistency of the time-series data is guaranteed.

QA/QC information

The data used for calculating emissions were obtained directly from the factories. Each factory has a quality assurance system in compliance with any of the ISO 9000 series. It should be noted that no such systems were operated in Hungary in the beginning of the 1990's.

The Cement Industry Association also verified the raw data and the calculation method. The data received from the Association and those published by KSH show a difference of a few thousand tons, which is presumably due to incorrect data processing at KSH.

The resulting national emission factors were compared to the default values recommended by the Revised Guidelines (0.4985 t/t for cement). This showed that the Hungarian specific factors are by about 20 %lower than the default value. This difference is attributable to the use of high amounts of additives, as mentioned above.

In case of wet process, where part of the CKD is removed from the system, this was taken into consideration on the basis of the residual $CaCO_3$ content of the CKD.

Recalculation

The whole time series was recalculated in 2003 through 2005. At the same time, uniformity

[2] Taking into consideration that although the highest uncertainty is associated with CKD, it affects a negligible proportion of the production volume.

of the calculation method was achieved by using a method based on raw flour, as mentioned above, and not on clinker, in all cases. Thus, consistency was achieved for the whole time series.

Upon the recommendation of ERT, we supplemented the emission calculation by carbon dioxide generated from $MgCO_3$. According to the information obtained from the Cement Industry Association, the limestone used in cement production contains very few, not more than 1-5% $MgCO_3$. The $MgCO_3$ content (in MgO) of raw flour was received for years 2002-2006 for each factory. The data of earlier years were calculated by averaging these data. Due to the recalculation, the emission of the sector changed from 1719.42 Gg to 1765.31 Gg in the base year.

Planned improvements

None.

4.2.2. Lime Production (CRF Sector 2.A.2)

Emitted gas: CO_2

Key source: none

Technology

This sub-sector includes quicklime production by limestone heating. During the heat transfer, the following reaction occurs:

$$CaCO_3=CaO+CO_2$$

Here, only CO_2 generated according to this formula is considered. CO_2 generated by firing processes is accounted under the Energy sector, Manufacturing Industries and Construction (1.A.2.B).

Methodology

The amount of CO_2 generated by this sub-sector was calculated according to the method recommended by the Revised Guidelines. The emissions were calculated using the production data received from the manufacturers and the proper stoichiometric ratio (0.785). Naturally, the corresponding stoichiometric ratio was used for slack lime ($Ca(OH)_2$) production data as well.

Uncertainties and time-series consistency

According to the data provided in the Good Practice, the uncertainty of the emission calculations for the recent years is estimated to 5 %. The uncertainty of calculations for the

initial years is higher than that. As a result of uniform calculation method, time-series consistency is ensured.

QA/QC information

The data received directly form the operators increased the reliability of the information.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.2.3. Limestone and dolomite use (CRF sector 2.A.3)

Emitted gas: CO_2

Key source: none.

Technology

This sub-sector includes processes in which calcinations (CO_2 loss) occurs as a result of heating the above two substances, obviously excluding the above two uses. Here, only CO_2 emissions generated by the degradation reaction are calculated, and gases from fuel combustion are included in sub-sector 1.A.2.B.

Methodology

The emissions were calculated according to the Revised Guidelines and using the correct stochiometric ratios. Identification of the activity data was complicated by the fact that the national data published by KSH also include other uses of limestone and dolomite (e.g., road construction). Since the emissions from most of the limestone used for purposes other than construction were already taken into consideration in the previous calculations, only limestone and dolomite used during various phases of iron production and limestone quantities used during the separation of sulphur were calculated here, and these values were obtained on the basis of the data received from the manufacturers. For years where such data were not available, the default value (250 kg dolomite/t iron) was used. Separation of sulphur has been carried out in one power plant since 2002 and in two since 2004.

Uncertainties and time-series consistency

According to the information obtained directly from the factory, the reliability of the data is

relatively high and the estimated uncertainty of the emissions is 2 %. For years where the default values were used, the uncertainty is higher. The recalculation ensures time-series consistency.

QA/QC information

No sector-specific information is available.

Recalculation

Till 2002 retrospectively, we received the data of limestone quantity used for separation of sulphur from the power plants, which enabled us to calculate the generated CO_2 emission.

Planned improvements

None.

4.2.4. Glass Production

Though the glass production is mentioned in the Revised Guidelines only as a source of NMVOC, based on the data explored according to the EU emission-trade directives, we determined the CO_2 emission of glass production. This is generated by the carbonates (mainly soda ashes) of the alkali metals (Ba, Li, Na, etc.) added to the melt in the course of glass melting.

Methodology

Considering the fact that all the glass factories take part in the emission-trade, the quantity of CO_2 supplied by them was considered emission in 2005. The data of total produced quantity were provided by KSH. The CO_2 emission is only 6 Gg representing only 0.1 per thousand of the total CO_2 emission. In order to achieve time-series consistency, we supplemented the inventory with data of earlier years as well. We chose a method of creating a specific emission factor from the data of 2005, and using this with the data of production known from statistics we calculated the emission of the sector retrospectively. This method gives quite rough estimates for the earlier years as it does not consider the different carbonate content of the raw materials necessary for the various glass types. Nevertheless, due to its small rate, it has no demonstrable effect on the whole inventory.

4.2.5. Brick and ceramics

Similarly to glass production, brick and ceramics production was put in the system also on the basis of emission-trade information. During manufacturing these products, CO_2 emission is generated from the degradation of carbonates in the raw materials on the one hand, and

from burning of materials added to bricks on the other.

Methodology

The same method was used to determine emission as in case of glass production with the difference that not all the participants of the sector take part in emission-trade. Thus, the reported CO_2 emission does not cover the whole sector. Thus, we calculated a specific emission factor on the basis of the values given in the trade system and applied this to the total produced quantity known from statistical data. With the help of this factor, the emission of the earlier years was also calculated. The emission in 2005 determined this way was 271 Gg which is 0.5 % of the total CO_2 emission. The following table contains the data of production and emission:

	1985	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***
Bricks and ceramics, kt	6,623.2	5,998.6	6,397.0	6,522.9	6,104.1	6,275.8	4,509.4	3,500.9	3,978.9	4,207.6	4,784.3
CO_2, Gg	477.0	432.0	460.7	469.8	439.6	452.0	324.8	252.1	286.5	303.0	344.5
	1996	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	
Bricks and ceramics, kt	4,217.0	4,222.7	4,437.6	4,162.3	3,021.9	2,728.3	2,300.4	3,018.6	3,277.1	3,763.0	
CO_2, Gg	303.7	304.1	319.6	299.8	217.6	196.5	165.7	217.4	236.0	271.0	

Table 4.3. *Bricks and ceramics production and CO_2 emission in Industry sector (1985-2005)*

4.3. Chemical Industry (CRF sector 2. B)

The relevant processes operated in Hungary include:

Ammonia production

Nitric acid production

Production of other chemicals: activated carbon (carbon black), ethylene and dichloroethylene.

In 2005 the production of the chemical industry increased significantly compared to the earlier trend. This is demonstrated well by the time series of the production data in the tables shown later. As a consequence, the emission of the industrial sector shows also an increase in respect of each greenhouse gas except for CO_2.

4.3.1. Ammonia production (CRF sector 2.B.1)

Technology

Emitted gas: CO_2

Key source: Level 1, Trend 1

Traditional ammonia production uses natural gas, the carbon content of which is released by the system in the form of carbon dioxide. Here, only emissions from the natural gas used as raw material is calculated and emissions from firing processes are taken into consideration under sub-sector 1.A.2.C. Among the factories operated in 1985, one was abandoned in 1987, another in 1991, and a third in 1992. As regards the existing factories, one uses obsolete technology and the other changed to a hydrogen/nitrogen-based technology in 2002. This technology does not generate technological CO_2. The ratio of the latter in the production is only about 5 %.

Methodology

Initially, production data published by KSH and default value recommended by the Revised Guidelines (1.5 to CO_2/t ammonia) were used for calculations. During ERT reviews (2002), it was repeatedly noted that calculation of ammonia produced is not sufficiently accurate and natural gas-based calculations are more reliable, as also recommended in the first place by the Revised Guidelines. Therefore, we contacted the factories and the emissions were subsequently calculated using the natural gas consumption data obtained from them.

The table below shows the production, use and emission data:

	Base year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Ammonia, kt	947.80	951.51	933.47	958.43	859.15	854.93	631.58	354.44	226.46	291.24	366.16
Natural gas, kt	782.01	803.53	769.48	773.02	695.82	709.47	553.82	334.15	230.05	281.18	334.30
CO_2, Gg	1,995.97	2,050.02	1,964.94	1,972.93	1,795.15	1,812.73	1,415.53	838.06	562.28	687.24	817.08

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ammonia, kt	376.19	422.37	411.98	350.35	317.26	427.78	394.38	289.40	281.78	369.32	397.39
Natural gas, kt	330.72	369.11	353.90	313.51	279.67	361.59	326.22	232.75	231.52	297.96	336.47
CO_2, Gg	808.32	902.16	864.98	766.27	683.55	883.78	797.32	568.87	565.87	728.26	822.38

Table 4.4. *Ammonia production, amount of natural gas used in the process and CO_2 emission in Chemical sub-sector (1985-2005)*

The figures above indicate that tCO_2/tNH_3 IEF value is around 1.9 to 2.5. It should be noted that the specific emission of the factory abandoned in 1992 was highly favourable (around 1.6). The effects of abandoning this factory are clearly reflected in the changes of the IEF (see CRF database): until 1991-93, this value shows a steady increase in line with the reduced production at the factories characterised by more favourable specific emissions.

Uncertainty and time-series consistency

Given that the amount of natural gas used in the process is easy to measure, and therefore the emissions can be easily calculated using the proper stoichiometric ratio, the estimated uncertainty of the resulting values is low (2 % to 3 %). Consistency is guaranteed.

QA/QC information

The quality and reliability of the emission data were greatly improved by using production data obtained directly from the factories.

Recalculation

According to the recommendation of ERT, we indicated the natural gas quantity instead of the previously used values containing the produced ammonia in the CRF Report. Since the input of the natural gas quantity in cubic metres was not possible, it was given in tones.

Planned improvements

None.

4.3.2. Nitric acid production (CRF sector 2.B.2)

Emitted gas: N_2O, (CO_2)
Key source: N_2O: Level 1, 2; Trend 1, 2 (such as: 2. N_2O emission from Industry).

Technology

Nitric acid is produced by oxidising ammonia. The process end gas contains N_2O and NO. In order to control the emissions, the latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide. Among the old factories using obsolete technologies, one was abandoned in 1989, another in 1992, and a third in 1996. Currently, two production lines are operated in the country – the older one was established in 1975 and uses GIAP technology. This represents the major part (about 80 %) of the production volume. Emissions from this process are measured. It is expected to be abandoned in 2006 because a new and more advanced production line will be installed. The

other existing technology represents only 20 % and has been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid).

Methodology

Measured emission data were not available for a long time. Therefore, during the first phase of the recalculation project, the default specific emission factor recommended by IPCC (6 kg N_2O/t nitric acid) was used. In 2004, an emission measurement system was installed at one of the factories and this has resulted in fundamental changes in the previously estimated values. Therefore, on the basis of almost one year of experience with measurements, the calculated emission factors of the factories using different technologies were between 10 to 19 kg/t. For calculation of emissions of the oldest factory (established in the 1950's), which was abandoned in 1989, the highest value recommended by the Good Practice was used (19 kg N_2O/t). 14.5 kg/t was used as specific emission factor for the two other abandoned factories and for the one to be abandoned in the near future (in the latter case, on the basis of measured emission data). For the combined factory, a value of 10 kg/t was used. Thus, the weighted average ranges between 13.06 and 14.46 kg/t in the time series, depending on the production volume. According to the Good Practice, the estimated specific emission of factories established before 1975 (such as the process in question) is between 10 and 19 kg N_2O/t.

The amount of carbon dioxide generated during the reduction reaction is so low (a few tens of tons: max. 93; and 64 in 2004) that it has no detectable effect on the inventory as a whole.

Production data were obtained from the factories for each of the 20 years in the time series. These and the emission data are shown in the table below:

	Base year	***1985***	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***
Nitric Acid, kt	1,015.07	1,053.46	996.79	994.97	967.18	893.47	734.34	379.46	212.55	312.33	462.10
N_2O, Gg	14.65	15.26	14.41	14.28	13.74	12.57	10.37	5.24	2.87	4.34	6.56
	1995	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***
Nitric Acid, kt	312.28	455.82	435.53	356.43	311.50	417.99	456.27	296.81	308.21	417.02	486.42
N_2O, Gg	4.35	6.21	5.98	5.02	4.40	5.79	6.29	4.04	4.27	5.70	6.26

Table 4.5. *Ammonia production (kt) and CO_2 emission in Chemical sub-sector (1985-2005)*

Uncertainty and time-series consistency

The level of uncertainty was significantly improved as a result of using data obtained directly from the factories and introducing an emission measurement system in the technology. The estimated uncertainty of the production data is 2 % to 3 %, while that of the emission factor is much less favourable, i.e., between about 30-40 %, however, this value is estimated to decrease to about 10 % by 2005 due to direct measurements. The time-series data may be considered consistent.

QA/QC information

The data received directly from factories greatly improved the quality of data. This is of particular importance because, in the past, we could obtain only limited production data from KSH (due to confidential technologies). Similar improvements were achieved by the newly introduced emission measurement.

Recalculation

According to the recommendation of ERT, we supplemented the database with the CO_2 emission generated by the reduction reaction mentioned above, but it had to be defined as a new gas, since it had “no place” originally.

Planned improvements

Given that emission measurements are to be continued in one of the factories, we may further increase the accuracy of the emission factor in the future on the basis of a longer data series.

4.3.3. Other chemicals (CRF sector 2.B.5)

Emitted gas: CH_4

Key source: none.

This sector includes the following technologies characterised by the following specific emission factors:

Carbon black:	0.0037 kg CH_4/t carbon black
Ethylene:	1 kg CH_4/t ethylene
Dichloroethylene:	0.4 kg CH_4/t dichloroethylene

Their contribution to the total emission is extremely low. Therefore, they are dealt with as one group. Earlier, the activated carbon process was a confidential technology because only one such process was operated in Hungary. Therefore, we could not calculate the related

emissions. Last year, we contacted the manufacturer and obtained production data and the value of the emission factor characteristic of the technology. Accordingly, the factory established in 1993, is working with furnace black process with the thermal treatment of the generated gas. Thus, the emission of methane is quite minimal. The factory had the methane emission measured, and as a result the value of emission factor was 0.0037 $kgCH_4/t$ product in contradiction to the default value of 0.06 recommended by GPG in 2006.
Using production data obtained form KSH and default values recommended by IPCC, methane emission was calculated for the other two processes. In 2005, this value was only 0.693 Gg (0.01 %). Comparing to the data of the previous years (0.4-0.5 Gg), the effect of production increase in 2005 can be observed here as well.

4.4. Metal Production, (CRF sector 2.C)

Emitted gas: CO_2
Key source: none

4.4.1. Iron and steel production, (CRF sector 2.C.1)

Technology

In this sub-sector, gases emitted by the iron/steel industry (sinter, iron and steel production) are calculated. During sintering (agglomeration), a mixture of iron ore, coke or carbon and limestone are agglomerated by heat transfer to obtain a material suitable for feeding into the furnace. During iron production, coke and carbonate-containing slag-forming additives are added to the agglomerated ore, and the mixture is reduced at a high temperature. This reaction releases CO and CO_2. Therefore, CO_2 is produced from two sources during the process: 1) from fuel, which also serves as a reducing agent, and 2) from carbonate-containing slag-forming agent (limestone or dolomite). During steel production, the carbon content of iron is reduced from 4-5% to below 1%. Also this is released in form of CO_2. Carbonate-containing iron ores are not used in Hungary. Therefore, we did not calculate such emissions.

Methodology

Partly for reasons related to the Hungarian traditions of energy statistics, the emissions of the sector from fuels are not included here but in sub-sector 1.A.2.A. The other reason justifying the use of this method is that no information is available as regards the distribution of fossil materials between use as a heat generator (i.e., energy production) and as a reducing agent (i.e., industrial process) during iron production. CO_2 released from limestone and/or dolomite

is taken into account under sub-sector 2.A.3 (Limestone and dolomite use). Iron and steel production data were obtained from the reports of the International Iron and Steel Institute and the similar European agency (EUROFER). Initially, limestone consumption data were calculated on the basis of the default value in the Revised Guidelines. In recent years data received from the factories have been used.

In order to make emission calculations complete, carbon dioxide releases from raw iron and graphite electrode of the electric arc furnace (EAF) during steel production were also calculated here. For these calculations, the following default values were used: carbon content of iron: 4%; carbon content of steel: 0.5%; specific emission of electrode: 5 kg CO_2/t steel. The latter was obviously included only in case of electro steel production. Emissions were calculated using the following formula:

$$CO_2\,(\mathrm{Gg}) = \left[\left(\text{Steel produced}\ (\mathrm{kt}) \times \frac{\text{carbon content, iron}\ (\%) - \text{carbon content, steel}\ (\%)}{100} \times \frac{44}{12}\right) + \text{electro steel}\ (\mathrm{kt}) \times 0.005\right]$$

Uncertainty and time-series consistency

The uncertainty of the emission is considered good since the calculations are based on data obtained directly from factories and associations. The time-series is consistent as the same method was applied each year.

QA/QC information

There is no sector specific information.

Recalculation

There was no recalculation.

Planned improvements

None.

4.4.2. Ferroalloy production (CRF sector 2.C.2)

Emitted gas: CO_2

Key source: none.

Technology

Upon smelting alloying additive and iron, together with slag-forming additives, a reduction

reaction occurs which results in release of CO_2.

Methodology

Fuels were included in sector 1.A.2.A, and only technological CO_2 emissions were calculated here. The production data were obtained from the KSH and 3.9 t CO_2/t alloy (ferrosilicon) was used as factor in accordance with the Revised Guidelines. In 1991, this process was abandoned.

Uncertainty and time-series consistency

The uncertainty of the estimated emissions is moderate because calculations were based on data other than direct raw material consumption data. The time series is consistent because the same method was used for each year.

QA/QC information

No sector-specific information is available.

Recalculation

There was no recalculation.

Planned improvements

None.

4.4.3. Aluminium production (CRF sector 2.C.3)

Emitted gases: CO_2, PFCs (CF_4, C_2F_6)
Key source: none.

Technology

During alum earth electrolysis, CO_2 is released from carbon anode. At the same time, fluorinated hydrocarbons are produced from cryolite as a result of anode effect when aluminium oxide concentration is low in the electrolyte of the reduction cell.

Methodology

PFC emissions were calculated using the Tier 2 methodology recommended, among others, by the Good Practice. Production data, including data on the sites already abandoned, were obtained directly from the factories. After the major political changes, two electrolysis plants were abandoned. The resulting changes in the volume of aluminium production (Søderberg

process) are shown in the table below:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Aluminium, t	73,862	73,875	73,507	74,643	75,186	75,13	62,877	26,818	27,879	29,647	31,91
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
Aluminium, t	33,468	33,674	33,71	33,64	33,85	34,591	35,294	35,038	34,349	31,783	

Table 4.6. *Amount of Aluminium Produced*

Measured emission data are not available in the factory. Thus, emissions were calculated using specific emission factors. The amount of emitted CF_4 was calculated by entering the appropriate data into the formula and by multiplying the result by the quantity of crude metal produced. 10 % of this was considered C_2F_6. Accordingly, the time series of CF_4 emission is as follows:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
CF_4, Mg	35.87	36.29	36.39	35.52	38.42	36.50	31.50	18.17	19.64	21.42	22.48
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
CF_4, Mg	21.48	21.41	23.05	23.60	28.40	26.75	27.19	25.38	26.96	28.01	

Table 4.7. *CF_4 emission in Aluminium Production 2.C.3 sub-sector (1985-2005)*

For each year, emissions were calculated for individual factories and the sum of these is used as annual total. You can found details description in ANNEX 3. The specific emission factor increased from the initial value of 0.49 kg/t above 0.8 by 2005. One of its reasons was that the emission factor of the factories, closed down in 1991, was more favourable than that of the remaining factory: the specific emission factor changed then from 0.5 to 0.68 kg/t. Due to the out-of-date technology of the factory operating further on, the trend of the specific emission factor shows an increasing tendency. After all, the factory ceased its production in the beginning of 2006. The amount of emitted CO_2 was calculated using the default factor (1.8 t/t) and the known production volume data.

Uncertainties and time-series consistency

The total quantity of produced crude metal is in the order of 10,000 tons and the accuracy of the obtained values is 0.1 t. The resulting uncertainty is below 1%. Whereas the effect numbers are recorded in the factory records, the effect time can be easily measured but is an average value. These are associated with a highly favourable level of uncertainty. According to the Good Practice, the uncertainty of the Slope value is about max. 1%. In summary, the

uncertainty of emission values is around 1% to 2 %. Data consistency was ensured by using the same calculation method for the whole time series.

QA/QC information

The factory operates an accredited quality assurance system. We have seen very well kept production records. The data made available to us were taken from these records. The company could provide data from almost 20 years of production without any difficulty.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.5. Consumption of Halocarbons and SF_6 (CRF sector 2.F)

Emitted gases: HFCs, PFCs, SF_6
Key source: HFCs:, Trend 1, 2.

4.5.1. Technology

HFCs (partially fluorinated hydrocarbons) are used in household and commercial cooling equipment, medical sprays (propellant gas), during production of foams used in construction/insulation industry, and as fire extinguishing agents. On the other hand, PFCs (fully fluorinated hydrocarbons) are used as solvents or as an ingredient of cooling mix, but they are rare. No HFCs or PFCs are produced in Hungary and such substances are imported. HFCs may be released to the atmosphere during the following work phases: filling, refilling, repairing, technical failure, direct use (spray, fire extinguishing).
PFCs were started to be used as an ingredient of cooling mixes in 1997. In 1998 and 1999, significant quantities were also used for adhesive tape production.
SF_6 is also imported and is mainly used as an insulation gas in electrical switchboards. The uses further include intermediate gas in double-glass heat insulation windows and production of optical bodies, etc. In Hungary SF_6 is not used as a cover gas in coloured metal foundries.

4.5.2. Methodology

In cooling industry, the imported HFCs are either filled into new equipment or are used to refill the cooling medium of installed equipment. It is assumed that the quantities previously released into the atmosphere are replenished and these are taken as the emissions.

Naturally, the refilling/handling loss should be added to this. In case of sprays, the entire quantities of propellant used in Hungary are taken as emissions.

In the beginning, the emission was calculated on the basis of a preliminary study prepared by László Gáspár, Institute of Environmental Management in 1998, later, with improving this, the calculation became more accurate.

Activity data

In the past, import data were obtained from VPOP (National Customs Office and Police). As regards recent years, the data and the uses have been taken into account on basis of the information received from commercial and/or user companies, as well as from the Association of Cooling and Air Conditioning Businesses (HKVSZ). Unfortunately, only a few companies have records on the quantities used for different purposes, and only estimated distributions are provided. The use of HFCs started in 1992, first in household refrigerators. Today, the use of HFCs as a cooling medium is already declining as a result of the ongoing change to R600 (isobutane), which does not have a greenhouse effect. Their use in commercial refrigerators and air conditioning systems, as well as their emission is sharply increasing.

On the basis of the latest available information, HFCs emitted during foam material production were also included. According to data obtained from the factory, the mixture (HFC 227ea/365mfc) is used for the production of both soft and hard foam.

In order to calculate domestic consumption, the quantity filled into equipment intended for export was subtracted from the total quantity of HFCs imported.

Emission factors

As regards household refrigerators, emission data were received directly from the manufacturer. In case of commercial and industrial equipment, the data required for determination of quantities used for filling new refrigerators and for refilling existing ones were received from trading companies. The latter value was taken as emission. For certain operators, the above ratio was determined by estimation in the light of the activities. In such cases, the emissions were calculated WITHOUT the use of emission factors.

As regards the production of foam materials, the recommendations of GPG were taken into consideration in calculating emission. The CRF program and the IPCC GWP Table of 2005 do not include GWP for HFC 365mfc, therefore it is not included in the database.

In case of SF_6, consumption and (sometimes) emission data were obtained directly from the users. However, only one company could provide data for the initial years and those for the others years were determined by estimation, taking due account of the general trends of industrial production. When a company could not provide data for a given year, this was determined again by estimation.

4.5.3. Uncertainties and time-series consistency

Trading companies, mainly involved in commercial refrigerators, gave estimates on the proportion of the imported HFC used for refilling that were associated with a high level of uncertainty and the error may be as much as 10 % to 20 %. As regards household refrigerators, the estimated uncertainty is a few percent. In case of medical sprays, the entire amount of HFC is released into the atmosphere and the associated uncertainty is low. The uncertainty of SF_6 emission may be considered favourable for 2000. However, for the preceding years, it may be rather high and even underestimated. Given that the same method was used for all calculations and the whole time series is available, the data may be considered consistent but are associated with different levels of uncertainty in different years.

4.5.4. QA/QC information

Instead of using import quantity data received from VPOP, we changed to using data obtained directly from users, thereby significantly reducing the associated uncertainty. The company manufacturing household refrigerators operates a quality assurance system of the ISO 9000 series.

4.5.5. Recalculation

In calculating the emission of HFCs used in foam blowing for the year 2005, we changed to the application of the method recommended by GPG and the specific factors. The data of 2004 were recalculated with the help of this method. The HFC-365mfc values, considered emission earlier, were taken out of the database.

4.5.6. Planned improvements

Further refining of consumption data is planned, primarily as regards the purpose of use in question.

5. SOLVENT AND OTHER PRODUCT USE (CRF Sector 3)

Emitted gases: (NMVOC,) CO_2, N_2O

Key sources: none

5.1. Overview of the sector

Primarily, emissions from paint and solvent uses were calculated in this sector. In addition, these include technologies related to N_2O uses. The figure below shows the time series of the emissions from the sector:

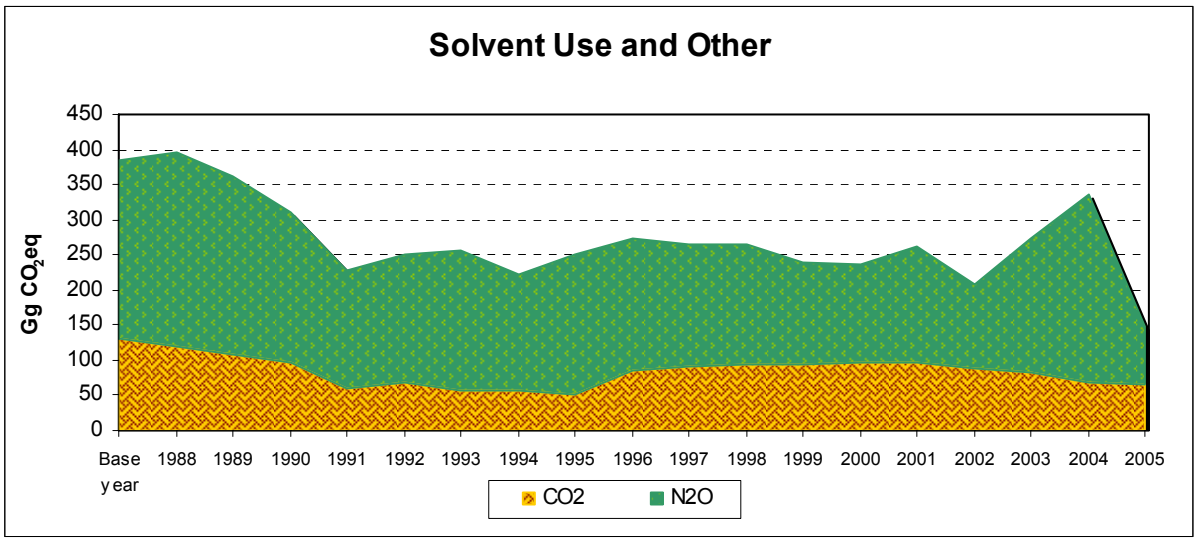

Figure 5.1. *CO_2 and N_2O emissions in Solvent and Other Product Use sector (1988-2005)*

5.2. Solvent Use (CRF Sector 3.1)

5.2.1. Technology

Paints and similar materials (lacquers, kits, glues) used in various sectors and households etc. contain diverse amounts of organic solvents. During use, they are applied to a surface and the solvents evaporate. The amount of the resulting NMVOC and that of the CO_2 released there are calculated.

5.2.2. Methodology

Data on paint and solvent uses were obtained from the data supplies of the Hungarian Central Statistical Office (KSH) or from Statistical Yearbooks, and, in addition to domestic

production, export and import activities were taken into consideration too. In 1996, the KSH altered the type of data collection, and this is the cause of increase that year in the diagram above. Compositions and solvent contents were previously coordinated with the Paint Industry. Paints, lacquers, kits etc. were classified into several groups according to the average solvent content. The Revised Guidelines provide little help for calculation of specific values. NMVOC emissions were taken to be equal to the amount with solvent. You can find detailed description in ANNEX 3. Specific emissions (t emission/t paint):

	Base year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NMVOC, t/t	0.331	0.338	0.334	0.322	0.303	0.309	0.325	0.283	0.294	0.260	0.247
CO_2 t/t	0.972	0.991	0.980	0.946	0.884	0.903	0.953	0.821	0.855	0.749	0.706
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
NMVOC, t/t	0.231	0.371	0.394	0.375	0.312	0.274	0.268	0.245	0.220	0.183	0.219
CO_2 t/t	0.656	1.084	1.154	1.095	0.898	0.781	0.762	0.689	0.613	0.499	0.616

Table 5.1. *NMVOC and CO_2 emission factors in Paint Application sub-sector*

The decreasing trend reflects the increasing proportion of water based paints. The emissions of chlorinated hydrocarbons used for degreasing and dry cleaning were determined by expert estimation to be 10 %. Emissions were taken into consideration on the basis of reports from the industry, and the amounts were calculated using the above ratio.

5.2.3. Uncertainties and time series consistency

The uncertainty associated with the amount of materials used is considered moderate. Primarily, this results from the fact that the calculations were based on national sales data not reflecting commercial stocks and the subsequent sales there from, instead of amounts actually used. However, the error created by this is balanced when averaged for several years. The error of this calculation is due to the lack of information on the exact solvent content and solvent composition of the materials used, and thus, to being limited to average values. As a result of the above, the uncertainty of the emission calculations is estimated to be medium. The time series consistency may be considered limited because KSH altered the method of data collection in 1996, and the breakdown of published data on uses differs from that applied before 1996.

5.2.4. QA/QC information

No sector specific information is available.

5.2.5. Recalculation

Emissions from this sector were not calculated in the years between 1985 and 1997. This was made up for during the two phases of recalculation, but the available data on the uses from the previous period are less detailed.

5.2.6. Planned improvements

None.

5.3. Use of N_2O (CRF sector 3.2)

5.3.1. Technology

This sub-sector includes less detailed technologies involving N_2O uses. One of the technologies considered is the use as an anaesthetic gas. Another, which was explored, is household whipped cream preparation. In Hungary, making whipped cream in siphons using N_2O cartridges is highly popular (although decreasing).

5.3.2. Methodology

Data on uses were obtained from the manufacturers. A significant proportion of cartridges manufactured for whipped cream is exported; thus, only domestic uses were considered.
N_2O production and domestic uses (tons):

N_2O, t	Base year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Anaesthesia	497	477	506	509	548	512	490	377	426	476	389
Cartridge	321	305	327	332	344	304	207	163	165	167	137
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Anaesthesia	499	470	430	441	371	375	476	331	578	828	228
Cartridge	145	137	131	113	96	71	61	56	45	38	39

Table 5.2. *N_2O emission (1985-2005, t)*

The cartridge refilling loss is high (approx. 30 %) and is taken into account in the calculations. According to manufacturer information, N_2O is released from the body in an unaltered form; therefore, the emission factor is set to 1.

5.3.3. Uncertainties and time series consistency

Production data are highly reliable because they are obtained directly from manufacturers.

Provided that the information on the unaltered form is correct, the emitted amounts are also highly reliable. The time series data are also considered highly reliable and consistent.

5.3.4. QA/QC information

No sector specific information is available.

5.3.5. Recalculation

In the past, no data were available for this sector. Thus, the entire time series should be regarded as “recalculation”.

5.3.6. Planned improvements

None.

6. AGRICULTURE (CRF Sector 4.)

6.1. Overview of the Sector

The agricultural activities contribute to emission of greenhouse gases through the following processes:

- Livestock: enteric fermentation and manure management
- Rice cultivation
- Agricultural soils
- Burning of agricultural residues

Emissions from energy consumption of agriculture activities (heat production, transport and fuel combustion of agricultural vehicles and machinery) are taken into account in the Energy sector.

Until the middle of the 1980s, agricultural production in Hungary was developing in accordance with the ecological and economic potential of the country and several sectors were producing under high quality standards in international comparison. In the second half of the decade, production started to decrease and underwent a drastic decrease after political changes in 1990. Between 1990 and 2000, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30% and the livestock by more than 50%. At the same time, production per hectare of agricultural land was also reduced in both of plant production and animal production. As a result of the shock-like decrease between 1990 and 1995, particularly in animal production, greenhouse gas emission from agriculture activities reduced significantly. In the period between 1996 and 2005, the level of production was essentially stagnating or slightly decreasing, particularly in animal production. In a few of years (i.e. 2004, 2005), in some sectors of plant production (i.e. wheat and maize) the production increased due to the significantly high yield owing to the friendly weather conditions. The greenhouse gas emission of agricultural activities was changed essentially in accordance with the activity data.

The trends in the emissions of sector are illustrated in the Figures 6.1, 6.2, and 6.3.

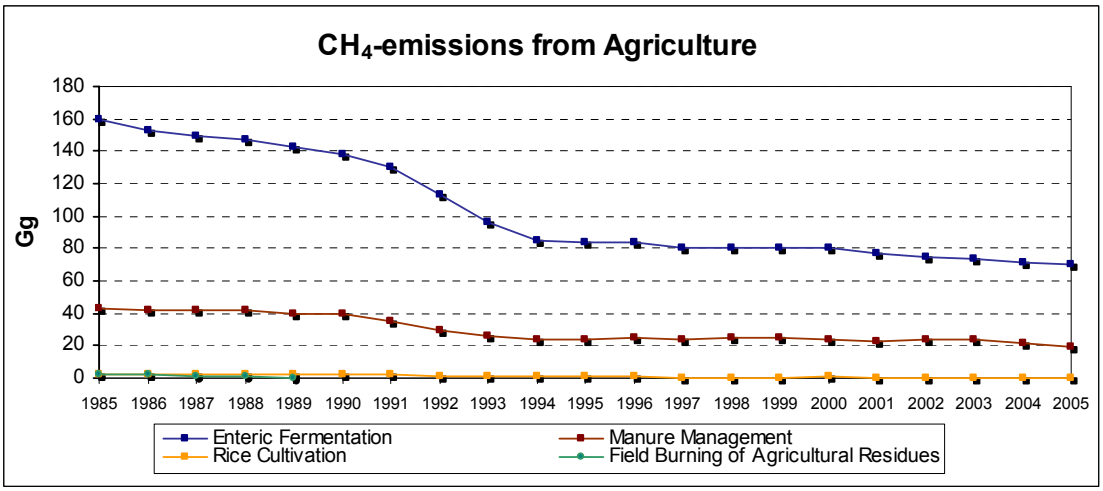

Figure 6.1. *CH_4-emissions from Agriculture*

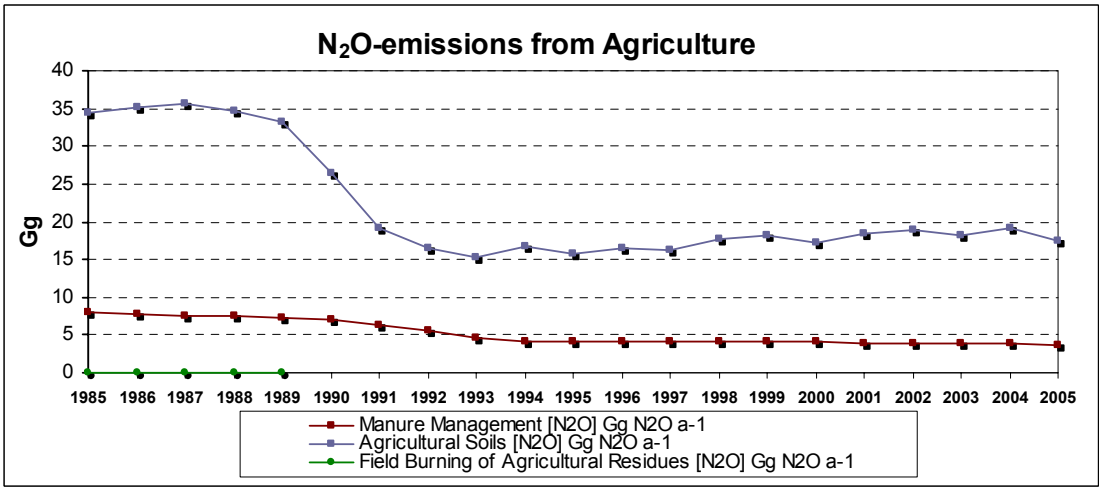

Figure 6.2. *NO_2 emissions from Agriculture*

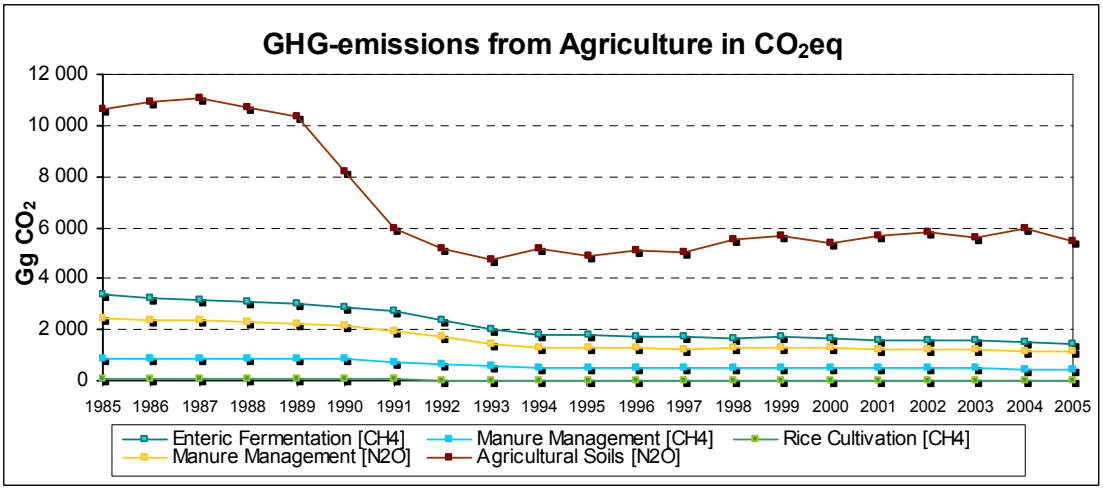

Figure 6.3. *GHG emission from Agriculture in CO_2 eq*

The constant decrease in methane emissions is the result of the constant reduction of the number of animals. Nitrous oxide emissions show similar trends until 1995, and has been essentially stagnating at that level since then.

The Figure 6.4. show the changes in greenhouse gas emission from the agricultural sector between 1985 and 2005 in comparison with the base years (1985 to 1987)

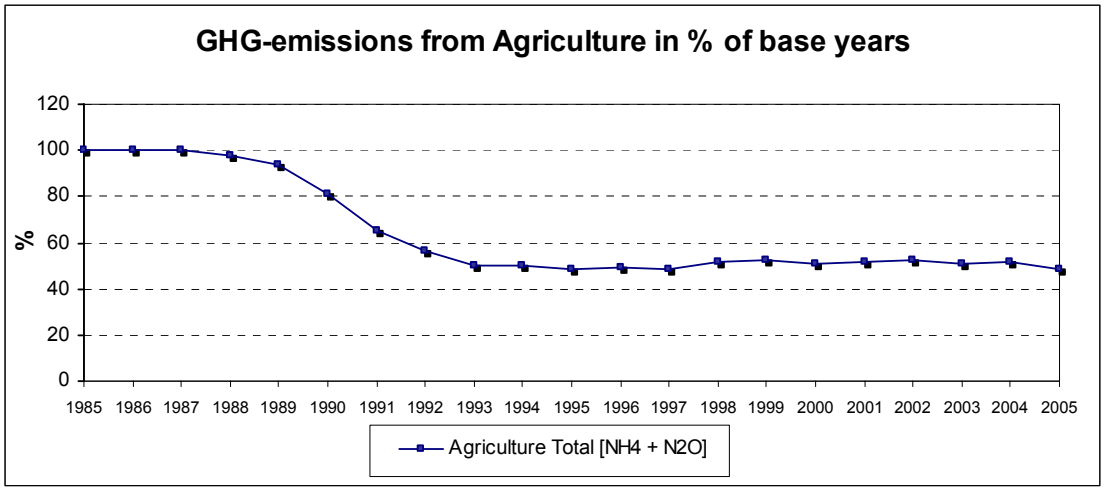

Figure 6.4. *GHG emissions from Agriculture in % of base years*

6.2. Enteric Fermentation (CRF Sector 4.A.)

6.2.1. Technology

Emitted gas: CH_4

Key source: Level 1, 2, Trend 1, 2

Enteric fermentation in animals (i.e. anaerobic cellulose degradation in the rumen of ruminants, in the colon of horses and rabbits, and in the caecum of poultry) produces certain quantities of CH_4, which is emitted to the atmosphere. The leading CH_4 emitters are ruminants, mainly cattle, with the most important category being dairy cattle. In addition to the number of animals, the level of production and feeding practices are the factors primarily influencing the amount of CH_4 from enteric fermentation.

6.2.2. Methodology

Emissions were calculated by using the Tier 1 method recommended by the revised Guidelines. Accordingly, the average annual population was multiplied by the emission factor.

Activity data

Livestock population were identified in line with the categories recommended by the Revised Guidelines (i. e., dairy cattle, other cattle, buffalo, sheep, goats, camels, horses, asses and mules, swine, poultry). Basic data were obtained from the Department of Production Statistics, Main Department of Hungarian Central Statistical Office (HCSO).

Since 2000, the HCSO has been registering the livestock three times a year (1 April, 1 August, 1 December), using a method which is equal to that of the EU. The average annual population was calculated according to the HCSO's recommendation (*Annex 3.4*)

Animals	Population (1,000 head)										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Dairy cattle	598	579	579	573	569	560	518	472	438	403	392
Other cattle	1,298	1,226	1,160	1,155	1,109	1,053	1,007	809	627	549	553
Buffalo	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Sheep	2,588	2,454	2,453	2,327	2,172	1,958	2,009	1,867	1,458	1,089	998
Goats	18	18	22	26	31	35	39	50	61	71	76
Camels	-	-	-	-	-	-	-	-	-	-	-
Horses	103	100	93	80	79	80	84	79	75	85	75
Asses and Mules	5.0	5.1	5.0	4.8	4.6	4.5	4.3	4.3	4.3	4.3	4.3
Swine	8,931	8,955	8,876	8,902	8,457	8,751	7,558	6,159	5,760	4,926	5,089
Total poultry	83,613	84,568	83,994	80,557	76,521	71,504	58,286	53,629	45,136	47,642	46,972

Dairy cattle	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Other cattle	396	387	381	385	390	377	345	330	309	300
Buffalo	535	512	494	484	443	416	431	428	424	420
Sheep	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
Goats	930	901	954	981	1,225	1,164	1,133	1,259	1,380	1,447
Camels	81	86	90	95	97	108	96	94	85	78
Horses	-	-	-	-	-	-	-	-	-	-
Asses and Mules	74	76	77	78	78	65	64	62	65	67
Swine	4.3	4.3	4.3	4.3	4.1	4.1	4.1	4.1	4.1	4.3
Total poultry	5,536	4,953	5,338	5,585	5,063	4,821	5,093	5,049	4,385	4,022

Source: HCSO (2005)

Table 6.1. *Animal population data between 1985 and 2005*

Emission factors

Table 6.2 contains the selected emission factors and the aspects of selection.

Animal	Enteric Fermen-tation	Source	Manure Manage-ment	Source
Dairy Cattle [(1)]	100	IPCC, Western Europe	6	IPCC, Eastern Europe
Non-dairy Cattle [(1)]	48	IPCC, Western Europe	4	IPCC, Eastern Europe
Sheep	8	IPCC, developed countries	0.19	IPCC, developed countries
Goats	5	IPCC, developed countries	0.1	IPCC, developed countries
Horses	18	IPCC, developed countries	1.4	IPCC, developed countries
Mules & Asses	10	IPCC, developed countries	0.76	IPCC, developed countries
Swine [(2)]	1.5	IPCC, developed countries	3	IPCC, Western Europe
Poultry	0.015	Own, judgement [(3)]	0.078	IPCC, developed countries
Buffalo	55	IPCC, developed countries	3	IPCC, Eastern Europe

Source: Rev. Guidelines Ref. Man. Table 4-3, p. 4.10; Table 4-4, p. 4.11; Table 4-5, p. 4.12,; Table 4-6, p. 4.13; (Climate: Cool)

Table 6.2. *The emission factors (kg head-1 yr-1) used for the calculation of the methane emissions from enteric fermentation and manure management:*

Notes:

(1) The production and feeding standards used in Hungarian cattle farming are close to the conditions indicated for Western Europe (Highly productive dairy sector feeding high quality forage and grain. Dairy cattle also used for beef calf production. Very small dedicated beef cow herd). Milk production standards are higher than the average Western European standards but are lower than the values indicated for Northern America. In the case of manure management methods, the predominant technologies in cattle farming are those characteristic of Eastern Europe (solid manure systems).

(2) Unlike in cattle production, liquid manure systems, which are characteristic of Western Europe, are used in swine production in Hungary. Therefore, in the case of swine, the factor recommended for Western Europe in the Rev. 1996 IPCC Guidelines was used for the calculation of CH_4 emissions from manure management.

(3) (according to Minonzio et al., 1998)

Currently, the default Tier 1 factors recommended for developed countries were used in the other categories for the entire period.

As regards the value of the "Dairy Cattle – CH_4 Emission Factor for Enteric Fermentation" parameter we are working on solving the problem raised by the Expert Review Team (ERT). The elaboration of the detailed calculation in accordance with the recommendation of the ERT is in progress in reference to the entire time series. Currently

the evaluation of the detailed data not collected so far but necessary to the calculations (body mass, net energy requirements, methane conversion rate) is in progress in reference to the entire time series. According to our preliminary calculations based on expert estimations the value of the "Dairy Cattle – CH_4 Emission Factor Enteric Fermentation" parameter can be between 99 kg CH_4 head^{-1} and 106 kg CH_4 head^{-1} in the base years and between 106 kg CH_4 head^{-1} and 114 kg CH_4 head^{-1} in 2004-2005 years. The parameters based on expert estimations and used to the preliminary calculations were the following (Table 6.3):

Parameter	Base years	2004-2005
Milk yield [kg yr^{-1}]	4517	6429
[kg d^{-1}]	12.4	17.6
DM (dry matter) intake of dairy cattle [kg head^{-1} d^{-1}]	14.5 - 15.0	15.5 - 16.0
GE (gross energy) content of food [MJ kg^{-1} DM]	18	18
Y_m (methane conversion rate which is the fraction of gross energy in feed converted to methane)	0.058 – 0.060	0.058 – 0.060
EF (NH_4-emission factor from enteric fermentation of dairy cattle) [kg CH_4 head^{-1} yr^{-1}]	99 – 106	106 – 114

Table 6.3. *Estimation of parameters for calculating NH_4-emission factor from enteric fermentation of dairy cattle*

Taking into account the abovementioned estimations and considerations, the default emission factor for Western Europe (100 kg CH_4 head^{-1} yr^{-1}) had been used for the entire time series in the emission inventory until the completion of the detailed calculations. Development of the country-specific emission factor for the entire time series will have been done by July 2007.

The statements on the dairy sector of the former NIR will be completed by the following:

- Similarly to the current situation, in the dairy sector there were feed rations used that were based on high quality forage and grain even in 1985.
- Feeding technology has been changed in the dairy sector in a way that currently almost only the TMR (total mixed ration) system is used.
- The composition of the rations has also been changed. The energy evaluation system currently used in ruminant feeding was introduced in Hungary in 1986. The requirements values were modified in 1999 and in 2004, too (beside other modifications, for example the maintenance requirement values of adult and young dairy and double-use cattle increased by 5%).

- There have not been any substantial changes in animal management systems.
- There has been significant improvement in genetic background of the dairy populations and the composition of the populations has also been changed. The significance of the double-use breeds has been decreased and the majority of the dairy farms having poor quality herds stopped milk production.

6.2.3. Uncertainty and time series consistency

As the non-recording-related error of the livestock population is less than 1% for both cattle and swine and around is 5% for horses and sheep, the recording-related error is negligible (HCSO, 2005). As the annual average numbers calculated on the basis of HCSO data essentially represent calendar years, i.e., periods between 1 January and 31 December, they may differ from those presented in the FAO Production Yearbook (FAO 1985-2003), which applies to 12-month periods starting on 1 of October and ending on 30 of September of the preceding year. Livestock number time series from 1985 to 2005 are practically consistent in spite of the several changes made to the data collection methods and timing, and to the categories used before 2000. Since 2000, data has been collected according to the EU standards in terms of both the method and timing, and the livestock categories.

Based on IPCC Good Practice Guidance 2000 (GPG 2000), the estimated uncertainty of the emission factors used for the calculations is ±20%.

Given the uniformity of the calculations in the entire period, the time series is consistent.

6.2.4. QA/QC Information

The quality of the inventories was improved by changing to the annual average numbers and by the application of factors better reflecting the Hungarian conditions.

6.2.5. Recalculation

In accordance with Section 6.2.2 methane emissions from the enteric fermentation of “Dairy Cattle” category were recalculated for the entire time series.

We recalculated the emission from the buffalo livestock, since the year 1995, because we gained additional information about the activity data (Source: Association of Hungarian Buffalo Farmers, 2006)

The errors, which were found on the course of the inventory review (i.e., activity data of the poultry livestock, in a certain years, between 2000 and 2003, the activity data of the usage of synthetic fertilizers and the quantity of the nitrogen excretion) were corrected. Most of these errors derived from data typing and checking errors. The whole time series

were recalculated, using rounding to the 6th decimal.

6.2.6. Planned improvements

We are planning a multistage, methodological development program, jointly with the Research Institute for Animal Breeding and Nutrition, titled “Development and regular review of country specific emission factors for the agricultural greenhouse gas inventory”. The first step of this program contains the solution of the following tasks:

- Method development for the calculation of methane emissions from the enteric fermentation of ruminants (cattle, buffalo, sheep, goat) in accordance with the Tier 2 method of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (2006 IPCC Guidelines).
- Method development for the calculation of methane emissions from manure management for ruminants (cattle, buffalo, sheep, goat) in accordance with the Tier 2 method of the 2006 IPCC Guidelines.
- Recalculation of methane emissions of the above mentioned categories for the period between 1985 and 2005.
- Determination of the accuracy of data and the error of the emission calculation.
- Elaboration of a proposal for the regular review of the applied methods.
- Assessment of the opportunities of the applying the Tier 3 method for the abovementioned categories.

Later, the other part of the agricultural greenhouse gas inventory will be developed as well, depending on financial and personal conditions.

6.3. Manure Management (CRF Sector 4. B.)

6.3.1. Technology

Emitted gas: CH_4, N_2O

Key source: CH_4: none; N_2O: Level 1

Animal manure is another important source of methane. Among others, nitrous oxide is released to the atmosphere, the amount of which depends on the conditions of manure management and uses.

6.3.2. Methodology

Again, the Tier 1 method recommended by the Revised Guidelines was used for the calculation of the emissions.

Activity data

See Section 6.2.2 and Table 6.1.

Emission factors

Section 6.2.2 and Table 6.2 (including the notes) contain the used emission factors for methane emissions from manure management and the background of their selection.

Table 6.4 gives an overview of the factors used to estimate the average annual nitrogen excretion of each livestock category. The factors were selected on the basis of expert consultations (Gundel 2004, Várhegyi 2004) and the relevant literature (Walther et al. 1994; Várhegyiné et al. 1999; Babinszky et al. 2002; Borka 2003).

Category	N_{ex} (kg N head^{-1} year^{-1})	Source
Other cattle	70	IPCC, Western Europe
Dairy cattle	100	IPCC, Western Europe
Poultry	0.6	IPCC, Western Europe
Sheep	20	IPCC, Western Europe
Swine	20	IPCC, Western Europe
Horses	60	Walther et al. (1994)
Buffalo	70	IPCC, Western Europe
Asses and mules	25	IPCC, Western Europe
Goats	18	Walther et al. (1994)

Revised 1996, Ref. Man., Table 4-20, p. 4.99, Walther et al. (1994), own estimate (Borka, 2003)

Table 6.4. *Amount of nitrogen excreted by each livestock category (N_{Ex})*

Table 6.5 shows the data related to the estimation of the amount of nitrogen excreted in different manure management systems. Table 6.6 shows the emission factors used for the estimation of the N_2O emissions.

Animal	Anaerobic	Liquid manure	Daily application	Solid manure	Pasture	Burning	Other system
Non-dairy Cattle	0	2	0	83	15	0	0
Dairy Cattle	0	4	0	88	8	0	0
Sheep	0	1	0	59	40	0	0
Swine	0	73	0	25	0	0	2
Poultry	0	26	0	74	0	0	0
Horses	0	0	0	60	40	0	0
Asses and Mules	0	0	0	60	40	0	0
Buffalo	0	0	0	60	40	0	0
Goats	0	0	0	59	40	0	1

Source: HCSO (2000), Mészáros (2000), Ráki (2003)

Table 6.5. *Amount of nitrogen excreted in various manure management systems (expressed as % of the total nitrogen excretion)*

Manure management system	Factor (kg N_2O-N kg^{-1} N_{ex})
Anaerobic lagoon	0.001
Liquid manure	0.001
Daily application	-
Solid manure	0.02
Pasture	0.02
Burning	-
Other system	0.005

Revised Guidelines, Ref. Man., Table 4-22, p. 4.104

Table 6.6. *Emission factors used for the estimation of the nitrous oxide emission from various manure management systems*

6.3.3. Uncertainty and time-series consistency

The same considerations apply for uncertainty as mentioned in Section 6.2.3. Regards to the N excretion of livestock, the amount of excreted N in various manure management systems and the emission factors, the following pieces of information are considered important:

In relation to manure management, the available parameters of Hungarian animal production systems were compared to the criteria listed for the Tier 1 factors in the Revised Guidelines. Hungarian conditions were analysed on the basis of expert consultations (Mészáros 2000) and a paper by Ráki (2003). This paper includes the processing of the following three databases:

- General Agricultural Census 2000 (HCSO)
- data from the legally required registration of agricultural producers in 2000 (this includes data for agricultural enterprises)
- a survey of animal production holdings performed in October and November 2001, which covered the capacity, capacity exploitation and the conditions of buildings and equipment. This survey allows conclusions to be drawn in conjunction with the entire animal keeping sector because it covers 70% to 100% of the livestock populations depending on the given category.

The finding that the majority of the buildings and equipment were built in the 1970s and 1980s applies to all livestock categories. After 1990, only a few new stablings were created, and a certain proportion of the existing ones underwent renovation. Accordingly, we believe that the selected parameters (excreted N, amount of excreted N in various manure management systems, CH_4 and N_2O emission factors) are representative of the entire study period. Thus, the time series can be regarded as consistent.

In 2007 the Government in the frame of the “New Hungary Rural Development Strategic Plan intends to support the modernisation of agricultural technologies, with special regard to environmental and animal welfare investments. The implementation of the Strategic Plan would be monitored and the possible impacts thereof taken into account in the course of the planned methodological developments (see Section 6.2.6).

6.3.4. QA/QC Information

Selection of the appropriate factors was assisted by experts in this field. The application of factors better representing the Hungarian situation improved the quality of the inventory. The recalculation, described in Section 6.3.5 resulted in further improvement.

6.3.5. Recalculation

The previously used category “Other Animals”, which contained buffalo, goats, horses, asses and mules, was omitted, and were considered separately, in addition the whole time series of the abovementioned categories were recalculated.

In calculating the amount of the excreted nitrogen in the different manure management systems, we recalculated the whole time series, applying rounding to the 6th decimal instead of applying only integer, rounded value.

See also Section 6.2.5.

6.3.6. Planned improvements

See Section 6.2.6.

6.4. Rice Cultivation (CRF sector 4.C.)

6.4.1. Technology

Emitted gas: CH_4

Key source: none

In rice cultivation, significant amounts of methane are released during the inundation period. However, since the production volume is very low in Hungary, the importance of rice cultivation in the greenhouse gas inventory is negligible.

6.4.2. Methodology

Methane emissions from rice cultivation were calculated using the production area and

the default emission factors recommended by the GPG 2000 (Ef_c= 20 g m^{-2}; SF_w=0.5; SF_0= 2). The total size of the production area was calculated on the basis of the official HCSO data.

As mentioned in Section 6.1 (Overview of the sector), the emission rates are low and show little changes since the base years. Since the total size of the production area has not changed significantly either (decreased slightly), the other sections are not discussed here.

6.5. Agricultural Soils (CRF sector 4.D.)

6.5.1. Technology

Emitted gas: N_2O

Key source: Direct: Level 1, 2; Trend 2;

Indirect: Level 1, 2; Trend 1, 2

N_2O, an intermediary product of denitrification and a by-product of nitrification, is generated as a result of microbial activity in the soils and waters. In both processes, only a small proportion of the converted nitrogen is released into the atmosphere in the form of N_2O. Nitrification and denitrification are closely related processes, and it is difficult to determine which of them produces more N_2O. Small changes in the environmental conditions may have a significant effect on the amount of N_2O in both processes. The nitrogen released to the soil via anthropogenic sources may participate in the nitrification/denitrification processes in the recipient soil (direct N_2O emission), or after having been transferred to other soils and water reserves (indirect N_2O emission) via various indirect pathways (leaching, runoff, ammonia and NO_x volatilisation and deposition). For a detailed review on N_2O generation processes in soils, see Granli et al. (1994), Bremner (1997) or Schmid, et al. (2000).

The most important factor affecting the nitrous oxide emissions from agricultural soils is the amount of nitrogen released into the soils via animal manure, synthetic fertilizers, crop residues, N-fixing, leaching and deposition.

6.5.2. Methodology

Calculation method

The calculation of direct and indirect N_2O emissions from agricultural soils was carried out on the basis of the GPG 2000, using the Tier 1b method.

Activity data

Activity data for the sector (total harvested production of plants, N-fertilizer) were obtained from the Agricultural Statistics Yearbook of HCSO, as regards N excretion and the amount of excreted N on the pastures, the data from Tables 6.4 and 6.5 were used.

The trend of the synthetic fertilizer usage and the harvested production of the most important crops are shown in the Figures 6.5 and 6.6.

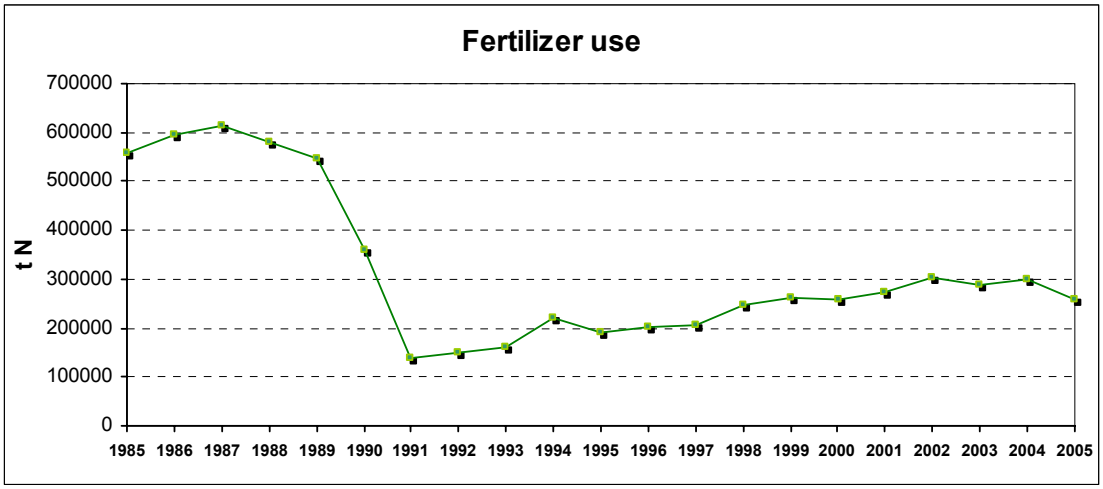

Figure 6.5. *The nitrogen content of the used synthetic fertilizer between 1985 and 2005.*

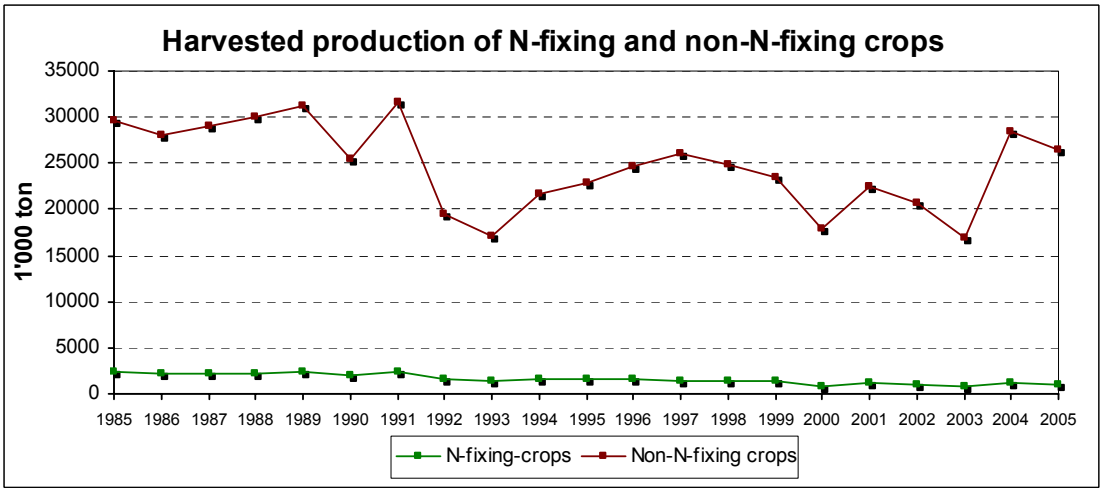

Figure 6.6. *The harvested crops of the most important crops, between 1985 and 2005.*

6.5.3. N_2O-emissions from Agricultural Soils (CRF 4.D.1, 4.D.2 and 4.D.3)

For calculating Direct Soil Emissions (from synthetic fertilizers, animal manure, N-fixing, crop residues and histosols), Emissions from Pasture, Range and Paddock Manure and Indirect Soil Emissions the following parameters were used:

Parameter	Dimension	Value
Direct Soil Emissions – Fertilizer		
$Frac_{GASFS}$	kg kg^{-1}	0.10
F_{SN}	kg yr^{-1}	GPG Eq-4.22
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Animal manure		
$Frac_{GASM}$	kg kg^{-1}	0.20
$Frac_{FUEL-AM}$	kg kg^{-1}	0.00
$Frac_{PRP}$ Average (1985-2005) Min (1996) - Max (2005)	kg kg^{-1}	 0.078546 (0.088366-0.102055)
$Frac_{FEED-AM}$	kg kg^{-1}	0.00
$Frac_{CNST-AM}$	kg kg^{-1}	0.00
F_{AM}	kg yr^{-1}	GPG Eq-4.24
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – N-Fixing		
$Res_{BF}/Crop_{BF}$ Non-Forage Crops Forage Crops	kg kg^{-1}	 1.50-2.10 0.00
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NRCBF}$	kg kg^{-1}	0.0142-0.0230
F_{BN} Non-forage Crops Forage Crops	kg yr^{-1}	 GPG Eq-4.26 GPG Eq-4.27
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Crop Residues		
$Res_O/Crop_O$ Non-Forage Crops Forage Crops	kg kg^{-1}	 0.3000-1.600 0.0000
$Frac_{DM}$, Non- N-fixing-crops	kg kg^{-1}	0.78-0.92

Parameter	Dimension	Value
$Frac_{NCRO}$	kg kg^{-1}	0.0028-0.0228
Res_{BF}/CropBF		
Non-Forage Crops	kg kg^{-1}	1.50-2.10
Forage Crops		0.00
$Frac_{DM}$, N-fixing-crops	kg kg^{-1}	0.850-0.870
$Frac_{NCRBF}$	kg kg^{-1}	0.0142-0.0230
$Frac_{BURN}$	kg kg^{-1}	0.00
$Frac_{BURN}$ for Cereals 1985-1989		0.1103-0.0220
$Frac_{FUEL-CR}$	kg kg^{-1}	0.00
$Frac_{CNST-CR}$	kg kg^{-1}	0.00
$Frac_{FOD}$	kg kg^{-1}	0.00
F_{CR}	kg yr^{-1}	GPG Eq-4.29
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Histosols		
F_{OS}	ha	0.00
EF_2	kg ha^{-1}	5.0
Direct Soil Emissions – Pasture, Range and Paddock Manure		
$Frac_{PRP}$		
Average (1985-2005)	kg kg^{-1}	0.078546
Min (1996) - Max (2005)		(0.088366-0.102055)
EF_3	kg kg^{-1}	0.02
Indirect Soil Emissions – Atmospheric deposition		
$Frac_{GASFS}$	kg kg^{-1}	0.10
$Frac_{GASM}$	kg kg^{-1}	0.20
EF_4	kg kg^{-1}	0.01
Indirect Soil Emissions – Leaching and Run-Off		
$Frac_{LEACH}$	kg kg^{-1}	0.30
EF_5	kg kg^{-1}	0.025

Table 6.7. *Parameters and values used for the calculation of N_2O emissions from Agricultural Soils*

Notes

Crops used for calculations of N-input into soils:

Non N-fixing crops: cereals (wheat, meslin, maize, barley, rye, oats, triticale,), potatoes, sunflower seed, rape seed, linseed, poppy seed, tobacco leaves, sugar beet, hemp for fibre, lucerne seed, seeds of grass, silage maize and green maize, mixed green fodder harvested in autumn, mixed green fodder harvested in spring, grass, onions, garlic, carrots, parsley root, tomatoes,

watermelon, melon, white cabbage, squash, sweet pepper, bonnet pepper, sweet corn, Hungarian red pepper,
N-fixing crops: bean, peas, lentil, broad-bean, lupin seed, soya-bean, lucerne hay, red clover hay, green peas, green beans.
Histosols (F_{OS}):
The histosols of Hungary are protected, they are not ploughed so we do not include them into the analysis.

6.5.4. Uncertainty and time-series consistency

According to the GPGUM (2000), the estimated resultant uncertainty of the sector is at least ±50%. These uncertainties are attributable to the activity data (to a smaller extent) and to the emission factors (to a greater extent). As a result of the recalculations, the time series can be regarded as consistent.

6.5.5. QA/QC information

The quality of the inventories was improved by switching to the annual average numbers and by the application of factors better reflecting the Hungarian conditions.

6.5.6. Recalculation

In accordance with the recommendation of the ERT the values of "Direct N_2O emissions from Animal Manure Applied to Soils", "Direct N_2O emissions from N-fixing crops" and "Direct N_2O emissions from Crop residues" were recalculated for the entire time series. See also 6.2.5. and 6.3.5.

6.5.7. Planned improvements

In the short term, development of a country-specific calculation method is unlikely. See 6.2.6.

6.6. Field Burning of Agricultural Residues (CRF Sector 4.F)

6.6.1. Technology

Emitted gases: CH_4, N_2O

Key source: none

Field burning of agricultural residues has been illegal in Hungary since the entry into force of Regulation No. 21/1986. (VI. 2.) of the Council of Ministers. According to the estimation of the regional inspectors of the Central (Budapest) Soil and Plant Protection Service, less than 1% of the area sown by cereals (i.e., not the entire arable area) is affected by illegal burning. Therefore, this is ignored during the calculations.

6.6.2. Methodology

In the lack of reliable and quantitative information, it was assumed that the rate of field burning in crop cultivation areas (only cereals) had been gradually decreasing between 1985 and 1989, and had been essentially eliminated in 1990. Accordingly, the following $Frac_{BURN}$ values were used for cereals: 0.11 (1985); 0.09 (1986); 0.07 (1987); 0.04 (1988) and 0.02 (1989). From 1990 on, $Frac_{BURN}$ was taken to be zero. As regards other parameters required for the calculation (dry matter content, carbon content, residue/crop product ratio, N-C ratio), the default values indicated in the Revised 1996 Guidelines (Ref. Man. Table 4-17) were used.

6.6.3. Uncertainties and time-series consistency

We can only have assumptions in connection with the uncertainty of our calculations for the period between 1985 and 1989. According to the Good Practice, the uncertainty of the factors is ±20%. According to the 6.6.1 paragraph, emission of this sector is negligible after 1990.

The given time series is considered consistent.

6.6.4. QA/QC information

No information is available.

6.6.5. Recalculation

Emissions for the missing years (1985 through 1990) were calculated. In addition, calculated figures were deleted from the databases prepared after 1998 due to prohibited activity on the basis of the information obtained upon involving additional experts.

6.6.6. Planned improvements

None.

7. LAND USE, LAND USE CHANGE AND FORESTRY (CRF sector 5.)

7.1. Overview of Sector

In the LULUCF sector, emissions and removals of forests in Forest Land and from soils of Cropland, Grassland and Other Land are estimated.

This sector is mainly characterised by CO_2 removals and emissions, whereas emissions of other greenhouse gases are minimal. The figure below presents the trend of the emissions and removals by sub-sectors.

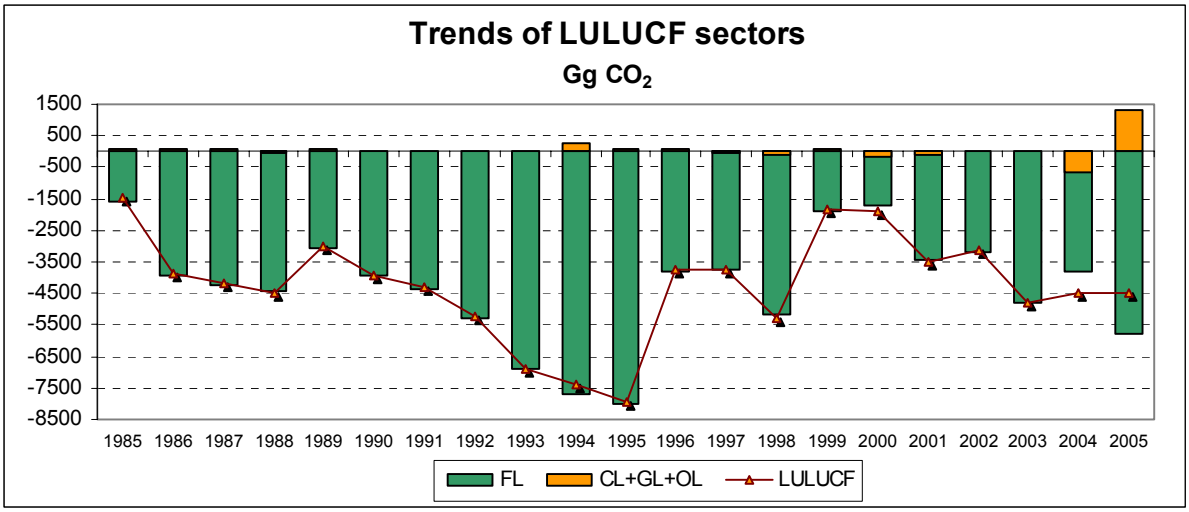

Figure 7.1. *Trends of LULUCF sectors*

7.2. Forest Land (5.A)

Forests cover some one fifth of the terrestrial area of the country. The total forest (FL-FL+L-FL, stocked plus unstocked) area in 2005 was 1983 thousand ha, while the stocked forest area was 1 790 thousand ha (see also Hungary's report to FAO's FRA 2005 at the www.fao.org website). Both in the graphs in this reports, as well as in the CRF tables, the area of the stocked forests is reported, as this is the area where carbon stock changes take place.

Of all the forests, more than 600 thousand ha were established in the last half century. After periods of slow increase of forest area, afforestations have been intensified recently (*Figure 7.2.*). Forest management has also a long history in the country, and most forests are more or less intensively managed. Therefore, and because there are practically no

unmanaged forests in the country (unmanaged forests called forest reserves occupy only a few thousand ha, i.e. 0.5% of all forests), all forests are considered as managed.

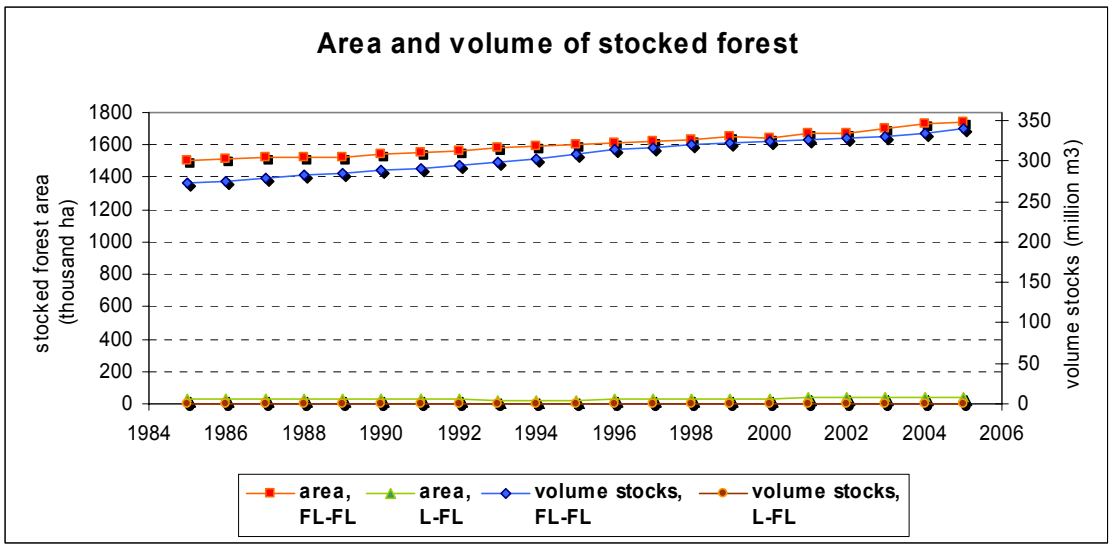

Figure 7.2. *Area and volume of stocked forest on land remaining forest land (FL-FL) and land in the transition category land converted to forest lad (L-FL). Note that values of L-FL are small, but not zero*

Forest management planning, as well as forest inspection are quite intensive in the country. During planning, practically all forests are surveyed once in every 5-12 years, depending on the tree species, which makes it possible to track the fate of all stands, and thus that of all forest land. All forest stands are thus accounted for, and all changes in the biomass carbon stocks of the forests, due to any causes from growth through harvests, natural disturbances and deforestation (see below), are captured, by the forestry statistics of each stand at least on a decade scale, and those of the whole forest area even on an annual basis. However, because the total forest cover has been growing for decades, there have not been any major deforestations, and, until now, there have not been separate statistics for conversions from forest to other land use. This means that, in the forest inventory statistics, loss of volume stocks due to deforestations are included in the statistics of total volume stocks of all forests. Note also that, in most cases when forest had to be cleared and land use type had to be changed, a new forest was established for replacement. Finally, abandonment of forest land is also regarded very rare, although it must have grown recently due to privatization of some 40% of all forests in the 1990's, but any increase or reduction of volume stocks on possibly abandoned land are included in the statistics of total volume stock change of all forests. Because of the above, and because statistics are only available at highly aggregate levels, land conversions to forest

land could be accounted for separately, but emissions and removals from any conversion from forest to other land use are reported together with “land remaining land” (see further details in the methodological sections).

Below there is a summary of all definitions that are generally applied in the methodology to estimate emissions and removals.

“Forest” is defined in Hungary as a land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. “Forest” includes stocked forest area, which is covered by trees, and also roads and other areas that are under forest management, but that are not covered by trees.

“Afforestations” or “reforestations” are activities that lead to conversion of non-forest land to forest land. The conversion can take place in a period of 3-10 years, depending on tree species and site. On the other hand, “deforestation” is a conversion of forest land to non-forest land, which takes place within one year.

“Above-ground biomass” is the total biomass of trees taller than two meters above the stump, including all branches and bark.

With respect to data sources, the activity data was taken from the National Forestry Database. This database contains data by species or species group and age class. Some emission/removal factors, e.g. wood density, are available by species or species group from literature, while only IPCC default values were available for other factors (see below).

7.3. Forest Land remaining Forest Land (5.A.1)

Due to the nature of the Hungarian forestry statistics, estimates of total volume of all forests in the country are available annually. Concerning land use changes, as mentioned above, only conversions to forest can be distinguished, because of the associated subsidies. Therefore, carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) can be estimated and reported separately, but those in lands converted from forest to other land uses (i.e. deforestations) cannot. However, as mentioned above, emissions from carbon stock changes in the biomass pools in deforestations are included in the emissions from biomass carbon stock changes in “forest land remaining forest land”.

7.3.1. Category description

Estimated main characteristics of the category can be found in *Table 7.1.*

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Table 7.1. *Emission and removals in the sub-category by gas and inventory year*

7.3.2. Methodological issues – CO_2 emissions and removals

The general approach to estimate emissions and removals in the forestry sector is based on the IPCC methodology (GPG for LULUCF). However, wherever it was possible, country specific data was used (Tier 2), and IPCC default values (Tier 1) were only used in a few cases. Emissions and removals leading to changes in the biomass carbon pools are accounted for however, due to lack of data, assumptions are applied with respect to other pools to comply with requirements to completeness.

Changes in carbon stocks in the biomass pools

Changes in carbon stocks in the biomass pools are estimated using the stock-change method of the GPG for LULUCF. This method is applied in the national greenhouse gas inventory since 2006. Previously, the changes had been calculated, following the early advice of the IPCC 1996 Guidelines, using the “IPCC default method” (better termed as a process-based method or growth and loss method) where data on changes due to growth, harvests and disturbances was used. However, as it was noted several times in earlier NIRs, relatively high uncertainties are inherent in these data due to different reasons, therefore, we changed for the stock-change method.

Fortunately, the National Forestry Database contains also statistics on total growing stocks by species and age classes. There are uncertainties around these statistics, too, however, they are regarded smaller, and systematic errors, i.e. bias, are considerably reduced when consecutive growing stock values are deducted to obtain stock changes. We note, however, that since growing stocks, and their change, incorporate the effects of all processes, no particular inferences can be made with respect to any of these processes.

Equation 3.2.3 of the GPG for LULUCF (IPCC 2003) has been modified to adapt it to the Hungarian conditions. The following equation was used to estimate carbon stock changes:

$\Delta C_B = (C_{t2} – C_{t1}) / (t_2 – t_1)$ and

$C_t = [V_t * D] * (1 + R) * CF$

where

ΔC_B = carbon stock changes of biomass (tonnes C)

C_t = carbon stocks at time t (tonnes C)

V_t = volume stocks at time t (m^3)

D = wood density, tonnes m^{-3}

R = root-to-shoot ratio (dimensionless)

CF = carbon fraction of biomass (tonnes C tonnes $biomass^{-1}$).

In Hungary, the main objective of the forest inventory is to enable the preparation of forest management plans. This can be achieved by surveying individual stands of about 5 ha of size. Each stand is identified on management plans, and the inventory data is stored in a computerized database.

Each stand is surveyed once in every 5-12 years, depending on tree species (fast-growing poplars e.g. are surveyed once in every five years, while slow-growing oak and beech stands only once in a decade). During the survey, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. These depend on species, age and site, and more accurate methods are usually used for stands of higher volume stocks. In years between surveys, yield functions are used to update volume stocks. As a result, (aggregated) volume carbon stocks are available for each inventory year. Note that some aggregated forest inventory information is available at the public website of the State Forest Service, www.aesz.hu, where, in addition to statistics and other information in Hungarian, a summary in English can also be found at

http://www.aesz.hu/index.php?option=content&task=view&id=295&Itemid=558.

Tree volume in the forest inventory is calculated from diameter and height of sample trees using volume functions by Kiraly (1978: Új eljárások a hosszúlejáratú erdőgazdasági üzemtervek készítésében. Kandidátusi értekezés, Budapest. In Hungarian), which are in turn based on volume tables by Sopp et al. (1974: Fatömegszámítási táblázatok. Mezőgazdasági Kiadó, Budapest. In Hungarian).

Concerning wood density, data by main species and species groups are available from literature (*Table 7.2*). Note that, although other elements of the methodology have been changed since last year, and the activity data vary from year to year, the same density values are used across all years for the sake of consistency. (Additionally, in a recent research project, measured density values for Black locust and black pine were very

close to the density values applied here, see Somogyi et al., 2005: Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects: Results of the monitoring case study in the test site in Hungary. CarboInvent, WP8.5 report, www.joanneum.at/carboinvent)

Species or spesies group	Wood density (t m -3)
Oak	0.665
Turkey oak	0.77
Beech	0.68
Hornbeam	0.79
Black locust	0.74
Other hardwood	0.59
Hybrid poplar	0.37
Indigenous poplar	0.395
White willow	0.33
Other softwood	0.56
Conifers	0.53

Table 7.2. *Wood density values for the main species and species groups in Hungary. (The source of the oven-dry wood density values is Babos, K., Filló, Z., Somkuti, E. 1979. Haszonfák. Műszaki könyvkiadó, Budapest. In Hungarian; Kovács, I. 1979. Faanyagismerettan. Mezőgazdasági Kiadó, Budapest. In Hungarian).*

Note that no biomass *expansion* factor is applied, because all wood volume (m^3) values in Hungary are estimated, and expressed, as total volume of trees including stem, all branches, twigs and bark, i.e. the volume of all aboveground parts of the trees (above stump, see above). To convert the total volume to above ground biomass, expansion is therefore not necessary, and only conversion is done. However, the same conversion factor is used for the whole tree, i.e. for all of its parts, and since twigs and branches may have density that is different from that of wood, this method may introduce an unknown, but slight bias.

With respect to the below-ground biomass, a general root-to-shoot ratio is applied. This is different from previous years, when carbon stock changes in the below-ground biomass carbon pool were not accounted for. In lack of proper data, IPCC default values are used in connection with expert judgement (Tier 1 methodology). Considering that the majority of the forests in Hungary are young, that the average volume stocks are 189 m^3 ha^{-1} (in 1990) and 219 m^3 ha^{-1} (in 2004), corresponding to an average aboveground biomass of 122 t ha^{-1} (in 1990) and 140 t ha^{-1} (in 2004), and that the IPCC default values have relatively high uncertainty, a conservative value of R of 0.25 is used for all species.

Concerning the carbon fraction of dry wood, the IPCC default value, i.e. 0.5 tonnes C

tonnes biomass^{-1} is used. Note that this value is different from the one used years before (0.45 tonnes C tonnes biomass^{-1}), because most publications report values closer to 0.5 than to 0.45, and the value of 0.5 was selected to get more accurate estimates. (This value of 0.5 has been consistently used already for several years.)

Changes in the carbon stocks of the dead wood, litter, soils and harvested wood products pools

In Hungary, no data has been collected systematically even in the main ecosystem types on dead wood, litter and soil. Although there is a soil monitoring that covers the whole territory of the country, it mainly focuses on agricultural soils, and sample density seems to be inadequate for forest soils to get numerical estimates. However, it seems justified to state that these pools continue to sequester carbon in the medium-term, rather than to lose carbon.

This is mainly due to two reasons: one is the sustained way of managing existing forests, which means that less wood is harvested than what is grown, and the other is that about one-third of all forests are afforestations since 1930, and most of these forests are still in their intensive growing phase. The effect can be easily seen from *Figure 7.3*, which shows the amount of estimated current annual increment and harvest statistics. Both of them seem to be biased, but it is not clear to what extent (the increment may be underestimated due to increased growth rates, and the harvests may be underestimated due to inconsistent reporting practices. It seems that harvest was underestimated more, at least in the last few years, as the new estimates demonstrate considerably lower removals especially if it is regarded that, unlike in the previous years, removals in the belowground biomass are now accounted for. their difference is large enough to claim sustained yield, which is also obvious from the growing trend of total volume stocks. This also means that more and more deadwood and litter is left in the forest, which in turn increase the carbon stocks of the soils. Additionally, no major disturbances or other processes are known that could result in substantial emissions from these pools. Therefore, although no quantitative estimates can be made on the increase, the Tier 1 assumption can safely be made that these pools are not sources, and their carbon stock changes are zero. (See also a recent presentation by

Somogyi (2006) at

http://afolu.jrc.it/events/Kyoto_technical_workshop/presentations/Z_Somogyi.pdf.)

Concerning harvested wood products, changes in the carbon stocks in this pool are not reported, either. The reason for this, in addition to lack of proper data and proper

methodology adopted, is the likely relatively small size of changes.

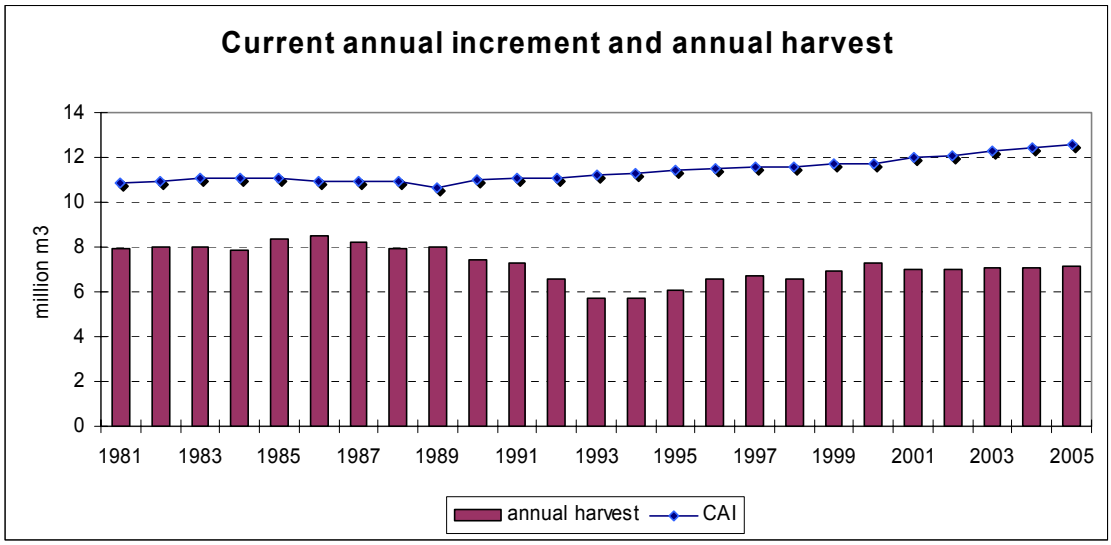

Figure 7.3. *Current annual increment (CAI, million m^3 yr-1) and annual harvest (million m^3 yr-1) in Hungary in the last decades. Data source: National Forestry Database*

7.3.3. CO_2 emissions from liming

Emissions from liming cannot be calculated for forestry separately, as only country-wide statistics are available. All emissions from liming are reported under agriculture.

7.3.4. Methodological issues – non-CO_2 emissions

Estimated non-CO_2 emissions originate from burning of slash on-site. Emissions from this burning are not significant, and are only reported for the sake of completeness and that of time series consistency with previous years. (CO_2 emissions due to this burning are accounted for in the biomass pool, because we use the stock-change method. Note that, theoretically, this includes carbon of CO and CH_4. However, these gases are reported (complying with the methodology of the GPG for LULUCF) because of their high global warming potential, because the double counting of the carbon is negligible, and also in order to comply with current guidelines on reporting.

The estimation methodology is based on the method suggested by the IPCC 1996 Guidelines, as well as equation 3.2.19 of the GPG for LULUCF. Carbon released is estimated using harvest statistics (m^3 of wood removed from forest, see the graph above, from which the amount of slash was calculated using average values by species, *Table 7.3* below) which were developed in former country-wide specific project for statistical

purposes). In addition, expert judgement was applied with respect to the fraction of slash burnt on site (0.2), and to the fraction that oxidised on site (0.9), finally, IPCC default value was used for the carbon fraction of harvested wood (0.5). The product of these values is first multiplied by default emission ratios by gas: 0.012 for CH_4, 0.06 for CO, 0.007 for N_2O, and 0.121 for NO_x. Then, for the nitrogen compounds, a general default value of 0.01 is applied to yield the total amount of nitrogen (N) released. Finally, the products obtained are multiplied by the appropriate molecular weight ratios, which are the following: 16/12 for CH_4, 28/12 for CO, 44/28 for N_2O, and 46/14 for NO_x.

inventory year	harvested volume	slash (from data by species)
	(m3)	(t)
1985	8,345,562	999,660
1986	8,500,991	1,012,554
1987	8,193,145	975,181
1988	7,960,397	945,002
1989	8,031,779	941,890
1990	7,415,162	867,795
1991	7,255,202	846,173
1992	6,588,569	775,646
1993	5,723,745	683,589
1994	5,717,468	697,710
1995	6,049,151	728,540
1996	6,603,733	791,934
1997	6,713,101	807,859
1998	6,578,931	786,791
1999	6,900,612	825,188
2000	7,287,456	883,913
2001	7,010,979	843,752
2002	7,013,167	850,311
2003	7,053,960	857,268
2004	7,094,753	864,225
2005	7,167,426	885,614

Table 7.3. *Harvest statistics for the inventory years*

7.4. Land converted to Forest Land (5.A.2)

7.4.1. Category description

As mentioned above, only conversions *to* forest can be distinguished of all land use changes, and thus, carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) are reported in this category. As this sector represents a very minor contribution to greenhouse gas emissions and removals, only carbon stock changes in

the biomass pools are accounted for. (We note here that, according to recent estimates, converting land from croplands does not entail any emissions from soil. See Somogyi, 2005: Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects. Results of the monitoring case study in the test site in Hungary. CarboInvent, WP8.5 report, www.joanneum.at/carboinvent; Somogyi, Z. – Horváth, B. 2006. Az 1930 óta telepített erdők szénlekötéséről. Erdészeti Lapok CLI.9:257-259.; and Somogyi, Z. – Horvath, B. 2006. Detecting C-stock changes in soils of afforested areas in Hungary. Presentation at the workshop Development of Models and Forest Soil Surveys for Monitoring of Soil Carbon. April 5-8, 2006 at Koli, Finland, www.metla.fi/tapahtumat/2006/soil2006. However, there are some indications that converting grassland to forest may lead to some emissions – see Horvath, B. 2006. C-Accumulation in the soil after afforestation: a key to CO_2 mitigation in Hungary? Submitted manuscript. However, the fact is that there are huge marginal lands or former croplands in the country, and, also because of biodiversity concerns, the overwhelming majority of all conversions occur on croplands, so no major emissions from soils are suspected during conversion.)

Estimated area of, and CO_2 emissions from this category are summarized in *Table 7.4* below.

Note that this category contains forests under afforestation until they are regarded as “forest land” in the national land cadastre. The time of the various stands in this category, i.e. the time that elapses from soil preparation until the stand is regarded as forest, changes by species, site, as well as climatic conditions and the appearance of pests/pathogens. This time can change between 2-3 years to 10+ years, the average being 5-6 years for slow growing species, and 3 years for poplars. The ratio of the various species in the afforestations in any given year of course keeps changing.

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inventory year	area (ha)	CO_2 (Gg)
1985	33,613	213
1986	32,656	106
1987	31,699	106
1988	29,785	213
1989	27,871	213
1990	27,680	21
1991	27,297	43
1992	28,063	-85
1993	20,599	390
1994	20,025	275
1995	22,513	-48
1996	27,106	-510
1997	30,359	-362
1998	30,168	28
1999	30,686	100
2000	31,210	-507
2001	36,169	-363
2002	42,021	-546
2003	44,054	-23
2004	43,976	237
2005	44,411	-473

Table 7.4. *CO_2 emissions and removals on land converted to forest*

7.4.2. Methodological issues – CO_2 emissions and removals

Methodologies used in this category are the same as used in the forest land remaining forest land category.

We note here again that, due to the nature of the stock change method, and also due to the fact that different lands move into, and out from, this category and that the time that the different land areas are accounted for in this category, the reported carbon stock changes are not due to, and cannot be interpreted as driven by, any processes like tree growth etc. alone.

7.4.3. Uncertainties and time-series consistency

The main objective of this uncertainty analysis, complying with that of the IPCC Guidelines, is to identify possible major sources of errors, and to indicate where efforts on development should concentrate in future inventories.

Information on uncertainties includes, among others, information on completeness, accuracy, and non-quantifiable elements. Concerning completeness, some emissions and removals could not be estimated, because of the reasons provided above, however, it is highly probable that their exclusion only results in overestimation of net emissions. With respect to accuracy, the estimated values are accurate as far as practicable, or are

conservative estimates (i.e., overestimate emissions, and underestimate removals), or conservative assumptions are used (e.g. in the case of carbon stock changes in soils, litter and deadwood. Finally, accuracy cannot always be quantified, partly because the error distributions are unknown due to lack of measured data, partly because calculation errors, or because assumptions cannot be quantified. However, calculation errors are highly unlikely, due to the double-checking of the data processing.

In 2003, Hungary applied quantitative sensitivity analysis to her LULUCF GHG balance, based on expert judgment. Uncertainties were assessed for the first time for the 2000 inventory.

The system of calculating reported values has been substantially modified compared to previous years. The new system allows for the use of even simpler sensitivity analysis than before. This is especially true if only the major sources of CO_2 emissions and removals are considered, which are the bulk of all emissions and removals. The reason for this is that the equation inherent in the calculation is simple: only volume stock changes, wood density, and carbon fraction factors are involved. It is thus easy to conclude that the system is equally sensitive to errors in the first two data types (the error in the carbon fraction factor is considered small).

The probability of errors in the various data is of course different. It seems that the activity data (i.e., carbon stock changes) are most important for the *trend* uncertainties, because all other factors are consistently applied throughout the years. Although no information is available on the accuracy of the volume stocks, it is likely that it is below 10%, and could only be improved with unduly high additional investments.

The uncertainty of the *annual* CO_2 emissions, as estimated based on the annual volume stock *changes*, can be quite high due to unknown uncertainty of annual estimates. Concerning the individual inventory years, actual values may deviate more from estimated values, as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests.

Finally, it can be concluded that many sources of error have been removed by switching from the process-based method to the stock-change method. Thus, it is expected that current estimates better reflect emissions and removals associated with forest land than earlier estimates.

7.4.4. QA/QC information

Almost all calculations are based on the activity data taken from the National Forestry Database. This database is the most accurate database in the country on the forests. It is updated annually, and the data is checked by many people at subsequent procedures

from field assessment to data processing. The constant development of field methods and informatics, improvement of checks, and increasing requirements on quality of work resulted in growing accuracy of the Database. Apart from double-checking of the data processing and correct application of IPCC assumptions and methodologies, no QA/QC were performed at the national level within the LULUCF sector greenhouse gas inventory, because it would have required undue effort at the current economic situation. However, data verification was, and is continuously, conducted concerning activity data (i.e. volume stock changes, see previous NIRs of Hungary). The applicability of background data and correctness of the arithmetic used was double-checked. All background information is archived by the expert in addition to the inventory agency. Thus, the correctness of the estimation methodology is in principle verifiable.

7.4.5. Recalculation

Because of change of methodology and data source (that was due to the start of the application of the GPG for LULUCF), all data was recalculated last year (i.e., in the previous submission). This lead to some differences between the former and the recent estimates for each inventory year. These differences were reported in the previous inventory report.

No recalculation was made this year. Recalculation may take place in the next few years if revisions of the activity data or the factors used will be conducted. However, we report some data either in another places, or in another format this year.

This includes that emissions from biomass burning were previously reported in category 5.G (Other), which are now reported under category 5.A.1 FL remaining FL / Biomass burning, controlled burning. This only changed the aggregated emissions for forest category, but not those of the LULUCF sector.

Emissions and removals under "CL converted to FL" were previously reported under "OL converted to FL". Additionally, we corrected a typing error (for the year 2004 and back) to have carbon stock change values in the respective columns where, erroneously, CO_2 values were entered.

Furthermore, cells in the CRF tables for other lands converted to FL categories were filled in with IE as we cannot distinguish the land-use category before conversions by our data. It does seem likely, however, that the majority of all conversions occur on croplands. This however resulted in some changes in the reported values.

Finally, we also included IE for all conversions from FL to any other land, because there are no separate statistics for these conversions. Note that, as mentioned before, emissions from deforestations are included in those of forest land remaining forest land.

7.4.6. Planned improvements

Further verification of both the activity data, as well as the factors applied seems still necessary, and is planned in the future. Also, a more complete description of the Hungarian forestry and forest inventory system is planned to improve documentation.

7.5. Cropland, Grassland, Other Land (CRF sector 5.B, 5.C, 5.F)

7.5.1. Overview of the sub-categories

Cropland is spatially the largest land-use category in Hungary. It represents predominantly the arable lands, the amounts of the area of orchards, and vineyards are 3.3% of the total agricultural areas. There wasn't significant cutting down of the vineyards and orchards, so we didn't detect any remarkable changes in the annual biomass production of perennials. Thus, there is no change of carbon stock in the biomass carbon pool in Cropland category in this year. So, this chapter covers CO_2 removals or emissions from the changing organic carbon content of Cropland, Grassland and Other Land soils.
The next table shows the total emissions/ removals of the Cropland, Grassland and Other Land soils.

Year	**Base year**	**1988**	**1989**	**1990**	**1991**
Emission/ Removal (Gg CO_2)	100.91	-15.03	65.27	13.82	47.01
Year	**1992**	**1993**	**1994**	**1995**	**1996**
Emission/ Removal (Gg CO_2)	45.83	7.39	278.93	50.59	68.02
Year	**1997**	**1998**	**1999**	**2000**	**2001**
Emission/ Removal (Gg CO_2)	-15.28	-78.09	80.21	-177.07	-91.66
Year	**2002**	**2003**	**2004**	**2005**	
Emission/ Removal (Gg CO_2)	40.92	-10.35	-647.99	1290.84	

Table 7.5. *Total emissions/ removals of the Cropland, Grassland and Other Land soils*

In 2005, our result would be 7.5 Gg CO_2, similar to the previous ones, if we took into account the categories used in the previous years (Cropland, Grassland) and this result can be fitted into the previous ones. The next figure shows the net carbon stock change in Cropland and Grassland soils from the year 1987 to 2005 years:

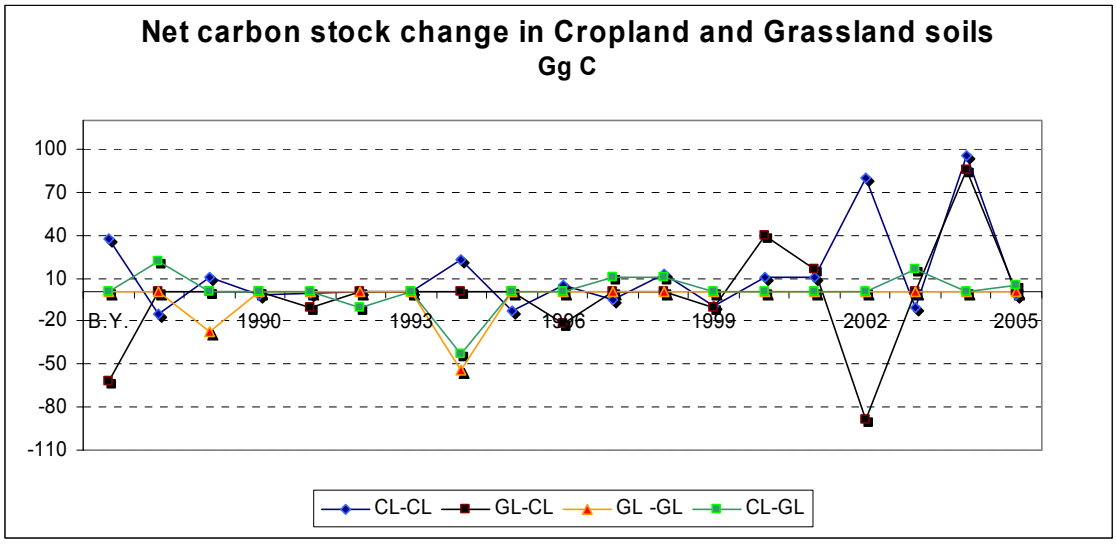

Figure 7.5. *Net carbon stock change in Cropland and Grassland soils from the year 1987 to 2005 years*

The building up of more than 1% of the cultivated soil (80 kha), caused 1283.33 Gg CO_2 in itself. This value concerns about 3 years, but we can't specify the excess amount for each year from the available data. The outlier isn't directly related to subtraction from cultivating but rather to the building up. Withdrawal of areas from cultivation is a tendency, which is not likely to stop, but if the rate of building up will be lower, the value will remain a single outlier.

The outlier results in the error of the estimation in 2005 being higher than the error of the previous years. The reason of it is that, the data source isn't standardized in statistically.

7.5.2. Methodology

Emissions were calculated in accordance with the GPG for LULUCF Tier 1 methods, therefore the source data are different form the previous ones.

Activity data:

In Hungary there are only a few fully comprehensive, official data collections, which are unsuitable for the estimation of the CO_2 change of the agricultural soils. Previously, making the inventory we also used inconsistent data base (i.e. soils type classification), because of the lack of sufficient data. Now, applying the new, method of GPG for LULUCF, statistical data published on the website of AKII (Agricultural Economics Research Institute, website: www.akii.hu) with a few complementary data are sufficient. The advantage of the new data base is the comparability, but the disadvantages are that the data collection isn't fully comprehensive and it contains some estimation in many

cases as well. The AKII collects data from questionnaires, which were submitted for subsidies complemented with commercial data. They don't monitor the extent of cultivated soil and the change of it directly, but revise it in certain years. So, it happened, that cultivated soil area, which was taken over by the establishment of industrial parks and fast-paced construction of high-way from 2003 were not recorded annually in the data base but were all added up and subtracted from the entire cultivated area in 2005. Until 2002, the extent of such lands was negligible, therefore the three years delay didn't cause an extreme change. Since 2003 the quantity of the subtracted lands caused outliers (extremities) in 2005. Consequently, the outliers derive from the nature of the data source, which isn't yet prepared to handle the land-use changes in a short time and is not a characteristic of the year. We hope that this will soon be observed, when publishing data.

Default reference soils and emission factors:

The soil classification is based on data origin from Ministry of Agriculture, Hungarian Central Statistical Office (KSH), database of the Research Institute for Soil Sciences and Agricultural Chemistry of the Hungarian Academy of Sciences: Soil Map of Hungary; St. Stephen University, Gödöllő: Reclassification of soil types as per genetic pedology into FAO's categories (Erika Michéli at al.). (Note: there was no systematic data collection for the required data. Time series of some types of data were compiled by periodical collection.)

The Hungarian national soil classification system classifies soils by genetic types, and these types are not comparable with types identified by the soil classification regimes of FAO or the USA. Therefore there was a project, titled "Modernization and international correspondence of Hungarian soil classification", founded by the Hungarian Scientific Research Found, managed by Erika Michéli. We used all of the references and reports of this project.

In Hungary, low activity mineral soils are occurring only as relict soil (type of oxisol) with specific land use. High clay activity mineral soils are chernozems, brown earth, rendzinas and some types of brown forest soil. Volcanic soils are acidic brown forest soils, black damps and rankers. Wetland soils are meadow soils and salt affected soils. Sandy soils and organic soils (marshlands and peat lands) are comparable with the Hungarian classification. The soil tables were prepared based on the old inventories so there is a possibility to compare the results of any year. All of the soils considered mineral soil (no tillage, warm dry small grain soils or salt affected soils are also mineral soils and these are not equal to the wetland as land use).

Hungary's territory is situated on the edge of warm and cool climate zones, as well as dry and wet ones. Habitats and land use systems are typical of the warm climate zone even on areas that belong to the cold region therefore the whole country was classified as being in the warm climate region. Land use systems typical of dry or wet regions were calculated separately.

The ecosystems of dry and wet regions are different (cultivation methods are different for areas lacking precipitation and with precipitation of over 600 mm per annum), therefore we treated them separately. However, ecosystems of warm and cool regions do not differ in Hungary (some tenths of degrees below or above 10 °C do not bring along any change in cultivation methods), and in general they are typical of the ecosystems of warm regions. As such, we disregarded this small difference of some tenths of degrees of certain areas and calculated only with the factor applicable for warm regions.

The systems listed below I. considered to cropland, and the systems listed below II considered to grassland.

I. Cropland systems

Warm dry irrigated crop, warm dry small grain with continuous cropping/conventional tillage, warm dry small grain with continuous cropping/no tillage, warm dry small grain/legumes with summer follow, warm dry vineyard and perennials, warm moist intensive grain product with high C input and high level tillage, warm moist intensive grain product with low C input and low level tillage, warm moist intensive grain product with medium C input and high level tillage, warm moist intensive grain product with medium C input and medium level tillage, warm moist vineyard and perennials.

II. Grassland systems

Warm dry pastoral range, warm dry successive grassland, warm moist pasture, warm moist reverted land.

Salt affected soils are classified under wet soils but their organic matter content is lower than that of other aquatic soils. We handled this soil type separately within pasturelands. Most of *peat lands* are under nature preservation and there is *no agricultural production taking place there*. The rest of them have been exploited (peat-winning). Vineyards and other perennials form an important part of Hungarian agriculture with intensive land management and flux of CO_2.

For ecosystems and emission factors as well as organic matter content of soils we took into account the values provided by the GPG for LULUCF, with the following deviations:

Perennials occupy significant areas in Hungary: vineyards and orchards, and these were

integrated into the ecosystems by taking the applicable cultivation level into account.
As already indicated, salt affected soils are also cultivated in Hungary, primarily utilized as pastures. By soil type, salt affected soils are aquatic (wet) and their organic matter quality complies with the category but the flux of organic carbon is different and would rather be classified as low activity soil. According to the list, however, this category includes tropical soil types. Therefore we had to create a separate category for salt affected soils, within aquatic soils. During amelioration the quality of salt affected soils may change and they may be classified under common aquatic soils.

III. Other land

This category covers the lands where cultivation was given up, because of building up, or where the building up will happen in a short time. (Further details are at the explanation of data source.)
We performed calculations in accordance with the Revised Guidelines, as compared to the average of twenty years, preceding the year under review.

CO_2 emissions from liming

There is no additional liming at all in Hungarians managed grasslands, because most of them are saturated with Ca. The grasslands situated on mountains, which are on acidic soils, belong to preservation areas, without any manure or agricultural management. So, the whole amount of the applied lime in the agriculture was taken into account in the Cropland category.
We determined the amount of liming matter used for amelioration of acidic soils with expert judgement, based on sales data. Beet potash is a generally used liming matter in Hungary, the composition whereof is changing and it contains some organic matter as well. The lime content of beet potash was indicated with the liming matter of limestone, and the organic matter content was built into the calculations by selecting the appropriate factors for cultivation. (GPG for LULUCF, Tier 1 method)
There are no reliable data on the amount of liming matter mixed into synthetic fertilisers as nitrate fertilisers are available with or without lime (the first is called “Pétisó”).
The lime content of liming matter and emissions of CO_2 therefore was taken into account by the application of the stochiometric ratio.
Other liming matter means the application of by-products from sugar-mills. Beet potash contains not only lime but organic matter as well, and this. Organic matter is taking into consideration in cropland input factors. Compared to previous years, statistics for 2005 indicate a lot more liming matter. The reason for this is that they presented matters used

not only for acidic soils, but for the improvement of salt affected soils as well. The effect of the latter on ecosystems has been duly taken into account (salt affected soil is turned into meadow-land); therefore, this fraction does not need to be accounted for here, in order to avoid double counting, out of the total, 73 000 tons of liming matter was used for the improvement of acidic soils. In addition, we also took into consideration the carbonate content of 35 000 tons of beet potash (from sugar mills) that is also traditionally used for soil amelioration.

Biomass burning

In Hungary, there is no controlled burning, because it is forbidden. Illegal burning, of curse, may occur, but we should not base official information on this opinion. Significant wildfires no registered during these years.

7.5.3. Uncertainties and time series consistency

Data used in our inventory are not consolidated and are often based on the farmers' declaration. As far as land size is concerned, smallholdings are more typical; there are only a few large estates. Many smallholders do not submit their declaration.

The precision of the estimation of soil carbon inventory became more adequate because of omission of soil type and the error caused it. Since there is connection not only between the soil type and the carbon content, but the land use and land use changes depend on the soil carbon content the accuracy of estimation of soil carbon content accord with the soil content estimated by revised 1996 IPCC Guidelines. Because of the error of the estimation is higher than the difference of the result from zero, we can't prove any significant emission or absorption of carbon dioxide by Hungarian soils. As a consequence, uncertainty is considered in general as high.

In the past couple of years several floods hit the Great Plain. Floods changed the carbon cycle of the soil and affected land use, so that statistical data do not correspond with reality.

In the autumn of 1993, a large part of arable land of Hungary (mainly plough-lands and nursery-gardens) was reclassified into downtown area. By this, the basis of data supply changed, therefore the results of two intervals (1987-1993 and 1994-2005) cannot be compared, and trends can only be examined separately from each other. As a consequence of reclassification, statistical data and calculations are related to a much smaller area.

Changes to the amount of carbon dioxide emitted or removed by soils can only be examined separately for these two periods. We performed variance analysis for both

intervals in order to establish whether we can talk about trends at all. We determined that based on the F-probe the contingent fluctuation of the results is so large that it does not facilitate the observation of any trend. According to estimation without statistical verification one could observe decreasing emissions and increasing removals in both periods. Correlation is so weak (r^2=0.30, r^2=0.16) that we cannot demonstrate any trend from the time data. One can observe that dispersion of data has significantly increased in the second period (by 30 %).

For the first period (between 1987 and 1993) we have very low values for the removal of carbon dioxide, which was presumably caused by intensive cultivation methods typical of the direct neighbourhood of settlements. This removal of carbon dioxide did not cease after 1994, but these areas are not reported any more among agricultural land due to their reclassification into downtown area.

The next graph shows the error of the total emission/removal without other land (66% deviation between the red lines), and the green ones is the total emission/removal.

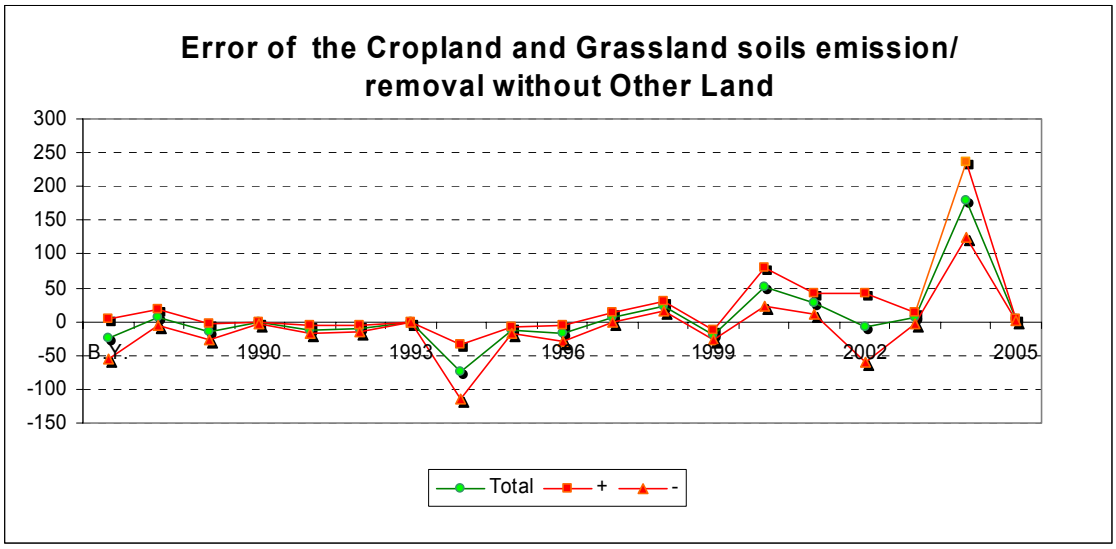

Figure 7.5. *Error of the Cropland and Grassland emission/removal without Other Land*

The uncertainty of our results, were counted in the following manner:

The main part of the error was caused by the classification of the land-use changes, because of the inadequate source data type, partly the data error. Moreover the determination of the organic matter content of the soil (selection of the default stock change factor for input of organic matter), effected less uncertainty. Therefore these errors were handled together with the estimation of the classification error and it was considered as an exact value. So, the classification error was taken into account according to the organic matter content.

The advantages of this method:

- The error of default values of soil carbon content is unknown, also unknown the deviation of real values of soil carbon content.
- Easy to avoid the systematic error of source data. (It causes an important problem, we can see in years 2005 result.)
- We can easy put the statistical data error to the error of classification
- We can establish the maximum error.

The disadvantage is that the distribution of the error estimation isn't possible to characterize by known statistical relationships, so it could case trouble in further statistical analysis.

As such, the estimated values of uncertainty were:

Matching soil types, land use type, inputs and management system: 25 %

Provided factors, with respect to temperature and precipitation conditions: 10 %

We show the procession of the error estimation in the next example:

At determined land use type, management system and input factors, according to the soil type estimated category the organic carbon stock of the soil is 100 t/ha. If this category was chosen on inadequately, it is possible, that it is maximum 130 t/ha or minimum 70 t/ha. So, the error may be 30% of the value. The probability of this error is 25%, so the misapplied default reference soil type can cause 0.25*0,3*100% error. The similarly calculated errors of the emission factors (land use type, management system, input) needed to be added. The errors of selection of the different emission factors are determined in a similar manner. These errors are summed up, so this sum means the error of a term which was characterized by the same emission factors and default reference soil characterized area unit and this value is approximately 20%.

The error of the outcome is the statistical error sum of the error of the terms.

7.5.4. QA/QC information

Sector-specific information is not available.

7.5.5. Recalculation

There wasn't any recalculation in this sector, but we checked all the CRF tables belonging to these sectors. We corrected them according to the NIR and the ERT's suggestions. The modification didn't cause changes in our results, only supplementation with correct abbreviations and comments.

7.5.6. Planned improvements

It is expected that as a consequence of our accession to the EU records shall become more homogeneous and accurate, which shall facilitate more accurate calculations – in the forthcoming years.

7.6. Wetland and Settlements (CRF sector 5.D, 5.E)

We haven't got detailed information connected to these categories, so we presume according to the ERT's suggestion that the CO_2 emission/ removal of these categories are negligible.

8. WASTE (CRF sector 6.)

This section discusses the emissions from municipal solid waste disposal (CH_4), municipal and industrial wastewater treatment (CH_4 and N_2O) and municipal waste incineration (CO_2, N_2O). One peculiarity of the sector is that a part of the carbon-dioxide emissions is generated from biological (biogenic) sources and since these biomass sources are re-grown, the resulting emissions are not treated in the inventory.

The major part of municipal solid wastes is treated by managed disposal and a smaller part by non-managed disposal, reuse, incineration or other means.

According to the relevant experience, the municipal solid waste is expected to increase by a small amount; an annual increase of about 1-3% is forecasted. The average specific municipal household waste generation rate is 1.0 to 1.3 kg/capita/day.

Since the last inventory, significant changes have been made in the emission calculations of the waste sector. Taking into account the recommendations of the Expert Review Team, the time series of the Solid Waste Disposal on Land (6.A) and Wastewater Handling (6.B) categories have been recalculated

8.1. Overview of the sector

The waste sector with 3941.81 Gg CO_2 equivalent represents 4.9% of total national GHG emissions. In contrast with other sectors, the emissions of waste sector show significant increase. In the base year (which is 1985-1987) the total GHG emissions from the waste sector amounted to 3000.84 Gg CO_2 equivalent which accounted for 2.6% of total national GHG emissions.

In all the years, the largest category is Solid Waste Disposal on Land, representing 72.5% in 2005, followed by Wastewater Handling (19.9%) and Waste Incineration (7.6%). Solid Waste Disposal on Land and Waste Incineration categories are showing an increasing tendency whereas the emissions from Wastewater Handling are decreasing as shown in Figure 8.2.

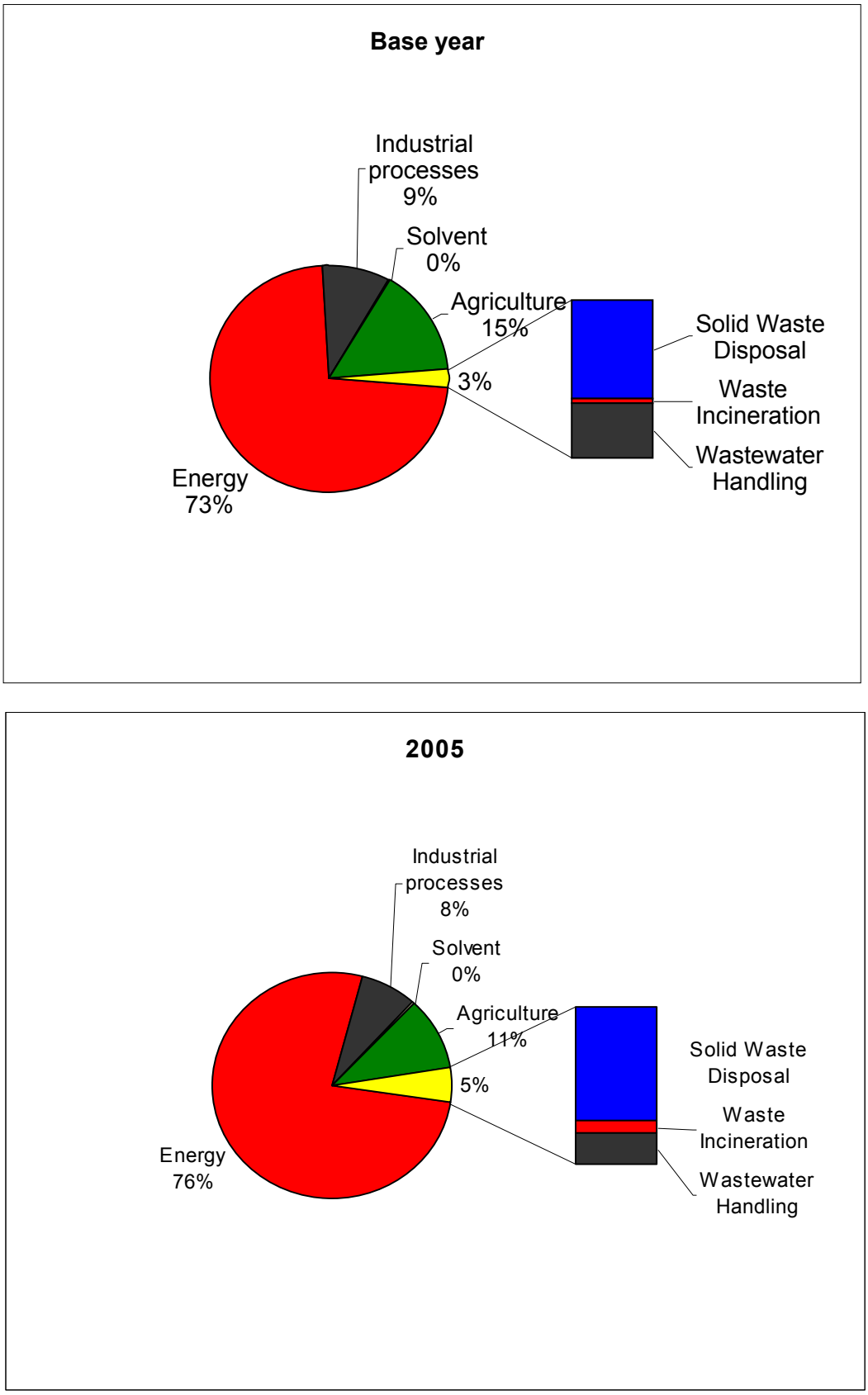

Figure 8.1. *The waste sector's contribution to the total national GHG emissions*

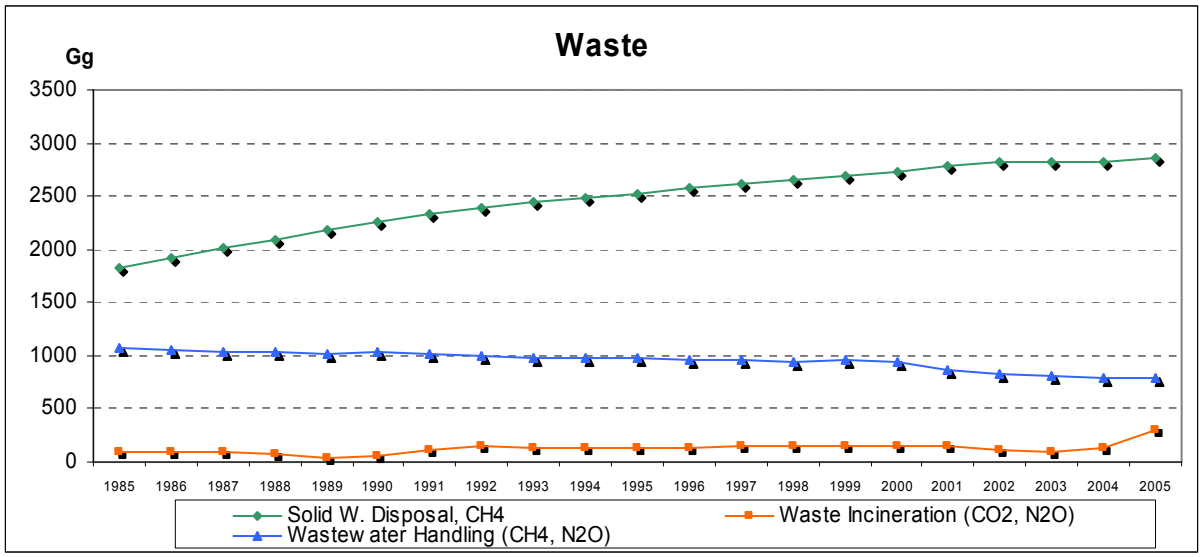

Figure 8.2. *The trend of emissions of the different categories in waste sector*

8.2. Solid Waste Disposal in Landfills (CRF sector 6.A)

Emitted gas: CH_4

Key source category: Level 1, 2; Trend 1, 2

8.2.1. Source category description

In case of managed disposal, the waste is disposed in landfills where it is compacted and covered. In these circumstances, *anaerobic* degradation occurs, during which methane and carbon dioxide is emitted. In advanced disposal sites, the generated methane is recovered by incineration or torching. Degradation requires several decades and occurs at varying rates. Since waste disposal is continuous, gas generation can also be considered continuous on a country scale.

The CO_2 generated in landfills is of biogenic origin and is thus excluded from the inventory. Under the conditions prevailing in landfills, CO_2 generated from wastes containing carbon of fossil origin is insignificant and direct incineration does not occur in landfills. Illegally disposed wastes are disposed in batches, in thin layers without compaction, in a fashion well-penetrable for oxygen. Therefore, degradation is aerobic and only carbon dioxide is produced. In accordance with the IPCC Guidelines, no CO_2 emission has to be included in this category.

The available data relate to the annual quantities of municipal waste that are regularly removed and disposed. Some 2/3 of this originates from households, while the remaining

1/3 comes from institutions, services and the industry. This latter is similar to household waste and can be treated together with municipal waste.

8.2.2. Methodological issues

For the first time, emissions were calculated using a first order decay methodology, as response to the recommendations of the ERT. For the calculations, the IPCC Waste Model from the 2006 IPCC Guidelines has been used.

Former inventories were based on a national method which can be described as follows. First, the fraction of organic compound was estimated based on official waste composition data. As the amount of the organic part of the waste, the quantities of the categories “paper”, “decomposing organic” and the half of the amount of “textile” were taken into account. It was assumed that 250 l of biogas is emitted for every kg of organic waste. It was further assumed that half of the emitted biogas is methane and the other half is CO_2 where the latter has not to be taken into account. Knowing the density of methane the emission could be easily calculated. Recovery was subtracted.

The national method is in a way similar to the IPCC Tier1 method based on the same assumption that all potential methane is released in the same year when the waste is disposed of. The FOD method, however, produces a time-dependent emission profile which may better reflect the true pattern of the degradation process as it is claimed by the IPCC GPG.

The methane emissions have been calculated with all these three methods (national method, IPCC Tier1 and FOD) for the entire times series, using the same background data. The IPCC Tier1 and our national method lead to similar results, the average difference is around 5%. At the same time, the FOD method gives significantly different estimates: in the base year, the calculated emission is only half of the value given by Tier1, and also for the last few years, the FOD estimates are around 15% less than the Tier1 estimates (see Fig. 8.3.).

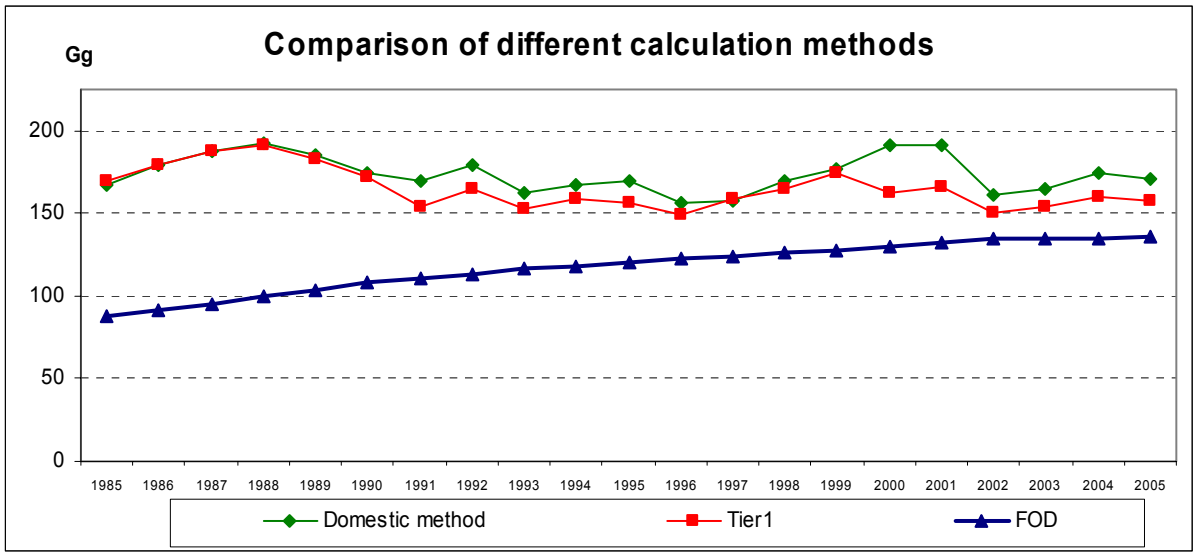

Figure 8.3. *The difference of the three calculation methods*

8.2.3. Used activity data and parameters

As basic activity data the *removed municipal solid waste* has been used published by the Hungarian Central Statistical Office in the Statistical Yearbook of Hungary and Environmental Statistical Yearbook of Hungary. However, these publications do not contain this basic information any more, but make a reference to the *Waste Management Information System* maintained by the Ministry of Environment and Water. This database is a new development and contains very detailed information on waste management practices in Hungary. The Waste Management Information System can be accessed via internet as well. (http://terkep.kvvm.hu/hirweb/) Data availability has been improved significantly, at least for the recent and future years.

(In the past, complete and obligatory data reporting on the collection of municipal solid waste did not exist in Hungary and the published data were estimations partly based on representative surveys. During the initial part of the calculation period, the authority procedures for waste recording were not uniform. In this system, which was based on self-reporting (self-registering), data were processed at varying detail and quality levels due to the lack of legal and technical regulations related to individual waste types. In addition, an overall central registry of industrial waste was missing and the rules related to such wastes were not laid down in any legal instruments).

Before 2001, the amount of removed solid waste was reported in volume units (m3), therefore these data had to be converted to mass unit. For the conversion, the gravimetric density (t/m^3) is an important physical characteristic. Between the base year

(which is 1985-87) its value was ranging between 0.3 and 0.2 t/m^3 based on the data by the Statistical Office. Both international and national studies suggested that the mass of municipal solid waste was hardly increasing while volumes were increasing drastically. In accordance with that, the gravimetric density is constantly decreasing – all over the world. These changes are attributable to the increasing amounts of paper and plastic in the packaging sector. In other words, this is the so-called loosening trend in MSW.

For the Tier1 method, we found enough waste amount data in the statistical publications. However the FOD method requires longer time series. The default first year in the IPCC Waste Model is 1950. As the eldest data we had found was for 1975, we had to extrapolate. For this purpose, we have used a similar pattern as in Figure 8.4. taken from a university textbook sponsored by the Ministry of Education and Culture which can also be found on the internet (http://www.hik.hu/tankonyvtar/site/books/b108/).

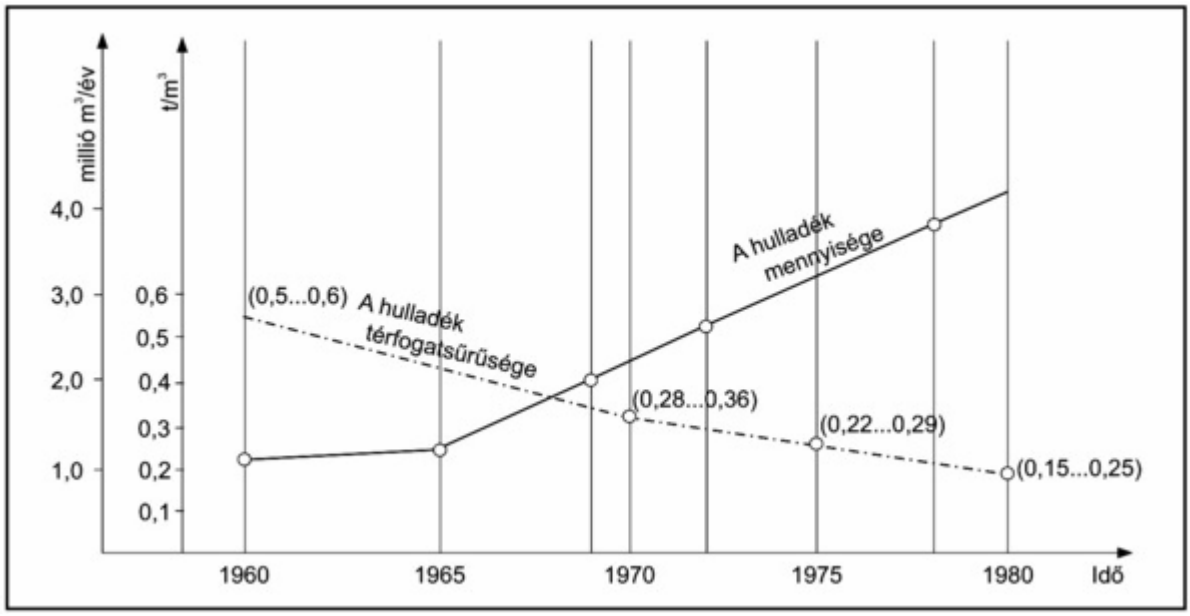

Figure 8.4. *The loosening trend of municipal solid waste in Budapest. The solid line denotes the amount of waste while the dotted line shows the decrease of volume-density.*

For conversion from volume to waste units, the following densities were used that are partly applied also by HCSO.

	1975-1985	From 1990	2000
Density (t/m^3)	0.3	0.22	0.2

As of 2001, data are collected and recorded in the more accurate mass units.

As regards *waste composition*, statistics only exist for the waste collected in Budapest and only from 1980. Having no other choice, these data were used for the entire country. For the FOD method the default values in the IPCC Waste Model were used for the year of 1950, but the measured values for 1980 and interpolation was carried out between these two years.

In the Hungarian statistics, the following waste composition categories have been used for a longer period of time: paper, plastic, textile, glass, metal, degradable organic, hazardous waste, other non-organic. These categories slightly differ from the requirements of the models, which had a minor impact on the selection of the parameters. Basically, the default values given in the IPCC 2006 Guidelines were chosen whenever possible. However, in the IPCC methodology the food and non-food (e.g. garden waste) fraction of the municipal solid waste are treated differently. As we have only one common category which is “degradable organic waste” that contains food and other organic waste as well, for the degradable organic carbon (DOC) content a value between the default values representative for food (0.15) and for garden (0.2) were chosen.

	IPCC GPG	IPCC 2006 GL.	Used value
MCF	1.0	1.0	1.0
DOC of paper	0.4	0.4	0.4
DOC of textiles	0.4	0.24	0.24
DOC of food	0.15	0.15	0.16
DOC of sew. sludge	-	0.05	0.05
DOC_F	0.77	0.5	0.5

The amount of recovered CH_4 was calculated on the basis of energy production data obtained from Energy Centre Hungary. These data in energy unit (TJ) were converted to mass unit as the amount of recovered methane by using the net calorific value from Table 1.2 in the 2006 IPCC Guidelines (Volume 2, Chapter 1), which is 50.4 TJ/Gg. It must be noted that the recovery data are not complete, further survey is needed.

The following table summarizes our calculations.

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1950	1800	22%	5%	30%		**0**	
1975	1872	19%	6%	30%		**58.9**	
Base year	**4018**	**19%**	**6%**	**28%**		**91.3**	**178.9**
1990	3518	20%	7%	32%		**107.8**	171.7
1991	3287	18%	3%	38%		**111.0**	153.8
1992	3367	19%	4%	39%		**113.5**	164.5
1993	3288	17%	7%	35%		**116.3**	152.7
1994	3436	18%	5%	33%		**118.3**	159.1
1995	3481	17%	4%	35%		**120.5**	156.0
1996	3294	19%	3%	32%		**122.6**	149.3
1997	3486	19%	6%	28%		**124.2**	158.2
1998	3575	18%	6%	31%		**125.9**	165.4
1999	3688	20%	5%	31%		**128.0**	174.7
2000	3799	14%	4%	41%	0.1	**130.3**	162.5
2001	3696	16%	3%	41%	0.1	**132.5**	166.1
2002	3717	16%	3%	31%	0.1	**134.7**	150.6
2003	3966	16%	3%	30%	1.2	**134.5**	154.8
2004	3978	15%	3%	31%	2.1	**134.8**	161.8
2005	4072	15%	3%	29%	2.1	**136.1**	159.6
Trend	**1%**					**49%**	**-11%**

8.2.4. Uncertainties and time-series consistency

Uncertainty can be estimated using Table 3.5 of the 2006 Guidelines. Accordingly, the following values were obtained:

Quantity of disposed municipal solid wastes:	>±10%
Degradable organic carbon	±20%
Fraction of Degradable Organic Carbon Decomposed	±20%
CH_4 correction factor (=1):	-10 %,+0 %
CH_4 content of landfill gases (0.5)	±5%
CH_4 recovery:	one order of magnitude
Half-life	±25%

The time series can be regarded as consistent.

8.2.5. QA/QC information

Following the recommendation of the ERT, higher tier method has been used. However, it must be noted that the change of method resulted in significant change in the CH_4 emissions estimate, although the same activity data and parameters were used.
Our calculations in the IPCC Waste Spreadsheet Model have been saved and archived for future reviews.
We can expect that by having better and more detailed data from the Waste Management Information System, the uncertainty of our calculations will decrease.

8.2.6. Recalculation

Recalculation of the emissions from this category was carried out for the entire time series using the FOD method. As a consequence, the emissions were halved in the base year and decreased by around 15% in the last years.

8.2.7. Planned improvements

More accurate and more detailed data surveys started in 2001 because Act No. XLIII laid down a new system of rules for Hungary, which has resulted in the amendment of several existing legal systems and the development of new ones since then. In the following years, the range of available data will increase and their accuracy will be significantly improved after the entry into force of a new regulation in compliance with the EU requirements.
We expect more complete recovery data in the future, and we will have waste composition data representative not only for the capital but the whole country.

8.3. Wastewater Treatment (CRF sector 6.B)

Emitted gas: CH_4, N_2O
Key source: CH_4: Level 1
N_2O: Level 2, Trend 2.

8.3.1. Overview of the sector

This sector covers emissions generated during municipal and industrial wastewater treatment. When the wastewater is treated anaerobically, methane is produced. Wastewater handling can also be a source of nitrous oxide and for the first time, N_2O emissions from human sewage have been added to the inventory.

8.3.2. Methodology

While estimating the methane emissions of wastewater handling, the key parameter is the fraction of wastewater treated anaerobically. However, complete and detailed data are not available for either municipal or industrial wastewater treatment. Therefore, methane emissions from wastewater treatment were calculated using the basic data available for us and the specific emission factors recommended by the 2006 IPCC Guidelines. Some wastewater data (COD values for the industrial sector, proportion of different treatment methods) based on measurements conducted by the authorities and emitter were obtained from the regional inspectorates for environment, nature and water. Beside that, we consulted with experts, visited a few wastewater plants and checked the calculations of the neighboring countries as well.

For domestic wastewater, the activity data - the quantity of Total Organic Waste (TOW) - was calculated by multiplying the population of the country by the IPCC default value of Biochemical Oxygen Demand that is BOD_5 = 60 g/person/day (Table 6.4 in Volume 5 Chapter 6 of the 2006 IPCC Guidelines). This BOD value was confirmed by Hungarian experts as well. In contrast with former inventories, this BOD value was used uniformly for the entire times series and for the whole country.

The activity data for industrial wastewater were the total output of wastewater [1000m3/year] and the Total Organic Wastewater [kg COD/year] which were collected by the regional inspectorates and further processed by the Research Institute for Environmental and Water Management (VITUKI). However, no precise data were available on the emission of industrial wastewater in individual sectors, especially for the initial years of the calculation period. Therefore, inter- and extrapolation were carried out using also the ratio of the total organic industrial wastewater [kg COD/year]) and the total quantity of wastewater which is known for 2000 (0.008976) and for 1987 (0.005555).

For the calculation of the *emission factor* (EF), the 0.25 kg CH_4/kg COD indicated in the Revised Guidelines was used as the maximum methane production capacity (B_o) for industrial wastewater, while in case of domestic wastewater, we have changed this value to 0,6 kg CH_4/kg BOD following the recommendations of the Guidelines. The choice of a proper methane conversion factor (MCF) was somewhat more difficult. Previous inventories have used a value of 1 for MCF as if all wastewater were treated anaerobically which was definitely not the case.

To remedy this situation, the following additional information was collected:

- The Fraction of population with no connection to the public sewerage system (source: Hungarian Central Statistical Office;

- Fraction of total wastewater treated at least biologically (secondary treatment) (source: VITUKI)

Using these additional activity data, the following assumptions were made:

In accordance with the 2006 IPCC Guidelines, for people using septic systems or any other domestic means (no connection to public sewerage system), it can be assumed that half of the BOD settles, therefore MCF=0,5 was chosen. (Table 6.3. in the 2006 Guidelines). In the base year, the portion of population connected to public sewerage system was less than 40% but in 2005, this number reached 64%. It must be noted, however, that the percentage of dwellings connected to public sewerage systems is still below the Central-European average.

It is further estimated, based on a study from the year of 2002, that around 20% of the wastewater/sludge is collected from those domestic systems and taken to treatment plants.

Usually, collected wastewater undergoes aerobic treatment in the plants. However, as we have not much information about the quality of those plants, MCF = 0.15 was taken as the mean value between the values characteristic for well managed and overloaded aerobic treatment plants. (Table 6.3 in the 2006 Guidelines). For untreated and only mechanically treated wastewater we calculated with MCF=0. In 2005, about 80% of municipal wastewater was treated at least biologically, while 17% was untreated and 3% mechanically treated, which is a great improvement. In 1997 only 56% of wastewater was subject to at least secondary treatment, and 40% was not treated at all.

Not enough information is available on the sludge generated during wastewater treatment and on the distribution of the degrading fraction between the water and the sludge phases. Therefore, the emissions from most of the generated sludge were calculated separately. However, the emissions from deposited sludge in landfills are taken into account in the SWDS category. Based on the data from the Energy Centre Hungary, the amount of recovered methane was subtracted.

The following table summarizes our new results that fit more into the range of values characteristic for our region.

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg methane	Emissions of domestic wastewater [Gg CH_4]	Emissions from industrial wastewater [Gg CH_4]
Base year	39%	55%	45%		38.85	1.48
1990	41%	50%	50%		37.42	1.30
1991	42%	50%	50%		37.26	1.17
1992	42%	50%	50%		37.11	1.06
1993	42%	50%	50%		36.92	0.96
1994	43%	50%	50%		36.71	0.87
1995	43%	50%	50%		36.51	1.05
1996	43%	50%	50%		36.30	1.22
1997	45%	44%	56%		36.05	1.07
1998	47%	42%	58%		35.40	1.05
1999	49%	33%	67%		35.63	0.94
2000	50%	33%	67%		34.76	0.90
2001	52%	36%	64%	1.71	31.84	0.68
2002	55%	33%	67%	2.62	30.01	0.68
2003	58%	38%	62%	2.68	27.99	0.64
2004	61%	27%	73%	3.43	27.44	0.61
2005	64%	20%	80%	3.83	26.81	0.53
Trend	***65%***	***-64%***	***78%***		***-31%***	***-64%***

For the first time, nitrous oxide emissions from domestic wastewater effluent were estimated using the IPCC default method and default parameters and emission factor. (Table 6.11 in 2006 Guidelines)

(Emission factor, (kg N_2O-N/kg –N) EF = 0.005, Fraction of nitrogen in protein (kg N/kg protein) F_{NPR} = 0.16 Factor to adjust for non-consumed protein: $F_{NON-CON}$ = 1.1; Factor to allow for co-discharge of industrial nitrogen into sewers: $F_{IND-COM}$ = 1.25)

	Protein consumption [g/capita/day]	Nitrous oxide emission [Gg N_2O]
Base year	100.0	0.67
1990	104.7	0.69
1991	102.0	0.67
1992	100.0	0.65
1993	95.0	0.62
1994	95.0	0.62
1995	95.0	0.62
1996	89.1	0.58
1997	89.1	0.58
1998	88.5	0.57
1999	91.1	0.59
2000	96.6	0.62
2001	93.9	0.60
2002	93.5	0.60
2003	103.0	0.66
2004	105.7	0.67
2005	106.0	0.68
Trend	***6%***	***1%***

8.3.3. Uncertainties and time-series consistency

Based on the above considerations, the uncertainty of the calculation of the emissions from household wastewater is relatively high. In the industrial sector, data became more reliable in the recent years as a result of the measurements. However, they do not cover the entire country, although the most important wastewater emitting sectors are included.

Uncertainty of the emissions from household wastewater treatment:

Per human populations -5 % to +5 %

BOD/capita -30 % to +30 %,

Maximum methane production capacity B_0 -30 % to +30 %

Uncertainty of the emissions from industrial wastewater treatment:

Quantity of industrial wastewater: -25 % to +25 %

Wastewater /unit of production COD/ unit of wastewater: -50 % to +100 %

Maximum CH_4 production capacity B_o : -30 % to + 30 %

Uncertainty of N_2O emissions

Emission factor order of 2

Per capita protein consumption ±10%

Used factors ±20%

Source: according to the recommendations of the Revised Guidelines and 2006 Guidelines, on the basis of expert estimates

The consistency of the time series has been improved.

8.3.4. QA/QC information

The data collected by the environmental authorities are checked by an independent institution (VITUKI) that further processes the data.

8.3.5. Recalculation

Initially, the emissions from this sector *were not calculated* for the period between 1985 and 1990, and this was completed during the first phase of the recalculation project. In addition, the emissions of the years from 1991 through 1997 were recalculated in the second phase.

In response to the recommendations of the Expert Review Team, the entire time series were recalculated in spring of 2007.

8.3.6. Planned improvements

According to a recently adopted legal instrument, operators are obliged to supply detailed data provided the rate of emission exceeds 15 m^3/day or the wastewater contains hazardous substances. As a result, more detailed information is expected to become available later on.

8.4. Waste Incineration (CRF sector 6. C)

8.4.1. Overview of sector

Emitted gases: CO_2, N_2O

Key source: none

This subsector covers emissions from thermal waste treatment. As a result of the criteria of waste incineration, methane emissions can practically be excluded and N_2O generation is also minimal.

8.4.2. Methodology

In Hungary, municipal waste incineration is carried out at only one place (at the Waste Incineration Works of Budapest) and it is combined with power cogeneration. Recently (2004-2005), the plant has been under reconstruction and operated at a reduced

capacity. After project completion, pollutant emissions from the incineration plant are reduced.

For the calculation of CO_2 from fossil sources, we followed the recommendations of the Background Paper (page 459) published as a complement to the Revised Guidelines, i.e., a ratio of 0.415 (the average of the range of 0.33 to 0.5) was selected as the fossil proportion of CO_2 assuming a production rate of 1 t CO_2/t waste. This way, one can also calculate the amount of CO_2 released from biogenic waste using the ratio of 1-0.415, of course. (The latter is not included in the total of the emission inventory.) On the other hand, the incineration plant also calculated the ratio of the fossil part for 2003, which was 0.517 in comparison with the default value (0.415). Therefore, distributions were calculated using this ratio from 2003 on.

The quantities of incinerated *municipal* waste and the time-series emissions of CO_2 *from fossil origins* are shown in the table below (Gg):

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Waste, Gg	244	219	243	197	71	152	253	340	316	338	330
Fossil CO_2, Gg	101	91	101	82	30	63	105	141	131	140	137
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Waste, Gg	330	339	356	352	348	353	258	192	160	303	398
Fossil CO_2, Gg	137	141	148	146	145	147	107	99	126	297	

The decreases in the incinerated quantity between 1988 and 1990 and in 2003-2004 are caused by the reconstruction of the incineration plant.

In 2004, the total amount of incinerated waste was 256 Gg; 160 Gg municipal waste was incinerated in the Waste-to-Energy Plant in Budapest, and 96 Gg other, mainly industrial waste was incinerated in other plants. The data from those incinerators are being processed. According to our previous estimation, the quantity of incinerated industrial waste was about 40 % to 50 % of the municipal waste. However, the more detailed data from 2005 show that the amount of incinerated industrial waste increases and it can be of the same magnitude as the amount of incinerated municipal waste. In 2005, the Waste-to-Energy Plant incinerated 303 Gg, while other facilities incinerated 339 Gg waste of different origin. The emissions from industrial waste incinerators were calculated with the same method, however using the default fossil ratio (0.415).

For the calculation of N_2O emissions, the value recommended by the Good Practice (8.33 kg/t) was used.

8.4.3. Uncertainties and time-series consistency

Data from the Incineration Works of Budapest are considered appropriate because they were obtained directly from the plant. Therefore, the ±5 % uncertainty recommended by the Good Practice is acceptable. The uncertainty of the default specific emission factors is likely to be higher. The uncertainty of N_2O emissions may exceed 100 %.

Data from hazardous waste incinerators and co-incinerators are also precise and measured data. Certain incinerators did not supply data or supplied estimations only.

8.4.4. QA/QC information

The Waste Incineration Works in Budapest operates a quality assurance system in compliance with the ISO 9000 series.

8.4.5. Recalculation

In the past, between 1991 and 2000, the entire quantity of CO_2 was calculated as fossil emissions. This value was not calculated before 1991. In line with the comments of the ERT, the revision of the methodology was completed in 2001, which allowed the completion of the calculation and recalculations for the whole time series during the period between 2003 and 2005.

8.4.6. Planned improvements

The survey of the industrial waste incinerators is still underway, on the basis of which we will be able to complete the emission data in the future.

9. OTHER (CRF sector 7.)

This sector not in use.

10. RECALCULATIONS

10.1. Explanations and justifications for recalculations

Although inventories have been prepared annually since 1994, the consistency of the entire time series (1985-2003) could be ensured only by 2005. All the changing reporting requirements were met even if with delays due to limited human resources. In addition to the recalculations, great emphasis was put on the determination of the Hungarian country-specific emission factors for the important technologies. All of these led to several recalculations of the inventories, thus the calculated values of the emissions changed accordingly. Since the details of those changes are described in the previous NIRs, this time we confine ourselves to the differences from the last submitted inventory.

The identification of the “base year” for Hungary represented a great deal of work as well. It required the preparation of databases for three years (1985-87) and the calculation of average values as the “base year” emissions. Unlike in other countries, where the base year is 1990, we additionally had to prepare inventories for 1988 and 1989 as well. As a result, we had to prepare and maintain inventories for six additional years.

While preparing the inventory for 2004 which was submitted in April 2006, we did not make any significant recalculations. However, based on the comments of the ERT, some data from the energy and agriculture sector were specified and modified. In the LULUCF sector we switched to the methodology according to Decision 13/CP.9. but only for the year of 2004. As a consequence, the data of this sector – and the aggregated data as well – showed difference from the earlier values and the time series became inconsistent. Similar problem came up regarding N_2O emission of the transport sector where new specific emission factor was used for the year 2004 but not for the whole time series because of the limited resources.

To get rid of the above-mentioned shortcomings, we improved the database in connection with the submission of the Initial Report as follows:

- In the energy sector, the methodology was further unified in the sense of using individual fuel-specific emission factors instead of the formerly applied “mixed” factors. As a result, the accuracy of emission data of the sector increased. Also for N_2O, the specific emission factor for the transport sector was modified for the

entire time series. At the same time, the emission factor for the lignite mined in Hungary was changed in the entire time series from the default value (105,6 t CO_2/TJ) to 113,2 t CO_2/TJ based on measurements of more than one year.

- The calculations for the basis years were made more accurate in the agriculture sector as well.
- Data gaps were filled in the category of wastewater handling for the base years.

We carried out lots of modifications in our data base according to the ERT's observations and a suggestion of the in-country review was hold on 5 to 10 of March in 2007. The details of the recalculations we have already reviewed in the chapters of the different sectors, so we will pan out about the main changes hereinafter.

The lack of the country specific emission factors have been a problem for us for long while in the sector of Energy. So, we determined them, based on published data and according to our knowledge of other air pollution elements. In case of N_2O we applied the emission factors suggested by the EMEP/CORINER Guidebook, considering the formerly existing less up-to- date and frequently out of technological equipments in Hungary. Therefore, our emission factors differed from those applied by other countries have similar capability. In the course of the review, it was questioned in many times, so we recalculate these categories of our inventory. We realized the next changes according to the last ERT's suggestion.

10.1.1. Energy sector

- In *Energy Industries,* sector default emission factors from Revised 1996 IPCC Guidelines and IPCC 2006 Guidelines are used in case of liquid and solid fuels for calculation of N_2O emission. Country specific N_2O emission factors were replaced by default factors in the *Other* sector, too.
- In place of uniform emission factors technology (engine type), specific factors are used to calculate both the CH_4 and N_2O emissions in *Road Transport* sector for base years and for the last two years. Through this, implied emission factor varies in function of modernity of actual car-fleet. To achieve consistent time series, calculation for the other years will be performed in the next inventory cycle.

Fugitive sector:

- Fugitive emission from coal mining was recalculated using newly provided domestic data from abandoned and active mines. From year to year, changing proportion of coal type in extraction was also taken into account. According to this,

the country specific emission factors decreased, and they are lower than the default values.

- According to the ERT's suggestions, the applied contractions (natural gas transmission and distribution) were dissolved, and rows of activity data were filled properly. According to this, fugitive emission from underground storage of natural gas is presented in 1.B.2.D. Other sector under "Underground storage". This relocation caused only small changes in emissions.
- Due to the ERT's suggestion, fugitive emission from thermal water has been relocated from the Other category in 1.AA.5. to Fugitive/Other category (CRF 1.B.2.D.)
- Calculation in fugitive emissions was extended with flaring in submission 2007 using default emission factors.

10.1.2. Industry sector

- The limestone used in cement production contains small $MgCO_3$ as well. According to the ERT's recommendation, we supplemented the emission calculation with carbon dioxide generated from $MgCO_3$.
- In Limestone and Dolomit Use sub-sector, we got data of limestone quantity used for separation of sulphur dioxide from the power plants till 2002 retrospectively, which enabled us to calculate the CO_2 emission from this activity.
- According to the ERT's recommendation in the course of the last review (2007), we reported the natural gas consumption in tones, instead of the previously reported values of produced ammonia, in the CRF Reporter.
- The production of nitric acid generates nitrous N_2O and NO as a by-product of high temperature catalytic oxidation of ammonia. The latter is reduced to nitrogen using natural gas and the carbon content of the natural gas is released in the form of carbon dioxide. We reported this amount in the CRF Reporter, additionally.
- Previously, the activated carbon process was a confidential technology. Last year, we obtained the production data from the manufacturer and the value of the emission factor characteristic of the technology.
- According to the latest data of the ETS, we refined the emission factors of the glass production as well as the brick and ceramics production and we recounted the whole time series applying these new values.
- Calculating the emission of HFCs we changed the applied method and the specific factors in accordance with the recommendation of the GPG. We cancelled the HFC-365mfc line in 2.F.2 Foam Blowing sub-sector from database and

transferred to the Cross-cutting information fraction (COMPLETENESS TABLE 9(b)), because the CRF Reporter and the IPCC GWP Table of 1995 do not include GWP for HFC 365mfc.

10.1.3. Agricultural sector

- Previously, the emission factor of the methane emissions from the enteric fermentation of „Dairy Cattle" was determined in the ratio of the milk yield. The ERT's expert had not accepted our method, so we recalculated our data for the whole time series applying the default emission factor for West-Europe, which is fits the Hungarian circumstances most of all.
- We corrected some mistakes and refined the livestock population of buffalos and poultries on the methane emission of the enteric fermentation from "Buffalo" and "Poultry".
- The previously used category "Other Animals", which contained buffalo, goats, horses, asses and mules, we itemized and recalculated the emission from those, applying more refined source data.
- According to the ERT's suggestion, the direct N_2O emission from the Agricultural Soil was recalculated as well.

10.1.4. LULUCF

In the first version of our data base, we have already applied the method of the GPG for LULUCF, so now we corrected some formal defects (i.e. replacing data into other row) and miscalculations.

10.1.5. Waste sector

- Regarding solid waste disposal, which is a key category, for the first time a first order decay methodology (Tier2) was applied, as a response to the recommendations of the ERT. For the calculations, the IPCC Waste Model from the 2006 IPCC Guidelines was used. As a consequence, the trend for emissions changed significantly: emissions in the base year were halved and decreased by around 15% in the last years.
- The calculation method of methane emissions in wastewater handling was revised, and recalculations were carried out for the entire times series. Accepting the recommendations of the ERT, new MCF was used and consequently the resulting IEF fits more into the range of values characteristic for our region.
- Additionally, nitrous oxide emissions from domestic wastewater effluent were

estimated for the first time from 1985 to 2005.

10.1.6. Implications for emission levels

The time series of the greenhouse gas inventories is subject to revision constantly, therefore it was changed many times before achieving its current form. Due to the high number of years to be calculated and modifications made, we could not deal with each modification in detail. However, for the characterisation of the accomplished modifications, the totals of the inventories (Gg CO_2eq, total excluding CO_2 from LULUCF) submitted at different time points are shown in the table below.

	A Y	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
Year 2000, Submission 2002	101,633	--	--	86,628	87,905	79,078	78,974	77,161	77,916	79,184
Year 2001, Submission 2003	113,074	--	--	95,820	87,905	79,078	78,974	77,161	77,916	79,184
Year 2003, Submission 2005	121,606	117,897	114,715	103,619	95,714	85,685	85,439	85,196	83,984	86,360
Year 2005, Submission 2007	**115,715**	**110,622**	**107,273**	**98,137**	**89,851**	**80,773**	**81,159**	**80,817**	**79,241**	**81,399**

	1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Year 2000, Submission 2002	76,853	83,687	86,546	84,338	--	--	--	--	--
Year 2001, Submission 2003	76,853	83,687	86,546	78,011	79,279	--	--	--	--
Year 2003, Submission 2005	84,408	84,530	83,735	81,150	83,967	80,842	83,283	--	--
Year 2005, Submission 2007	**79,442**	**78,976**	**79,132**	**77,340**	**79,111**	**77,054**	**80,284**	**79,204**	**80,248**

Table 10.1. *Recalculation differences of National Total GHG emission without CO_2 from LULUCF* *Note: AY =average of 1985-87 and BY=average of 1985-87 but 1995 for F-gases*

The figures demonstrate that the consistent database for the entire time series formed due to significant qualitative and quantitative modifications, until 2005.

In 2006 and 2007, the above mentioned recalculations resulted the following changes in the time series of the total emissions. (Gg CO_2eq, total excluding net CO_2 from LULUCF):

Submission	Base year (1985-87)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
2006 April	122,146	122,985	121,484	122,301	117,477	114,347	103,375	95,392	85,231	84,989	84,940
2006 Sept.	123,067	123,931	122 390	123,213	118,129	115,032	104,123	95,987	85,879	85,730	85,819
2007 April	116,315	117,433	115,731	116,113	111,302	107,920	98,735	91,678	82,455	82,965	82,723
2007 May	**115,604**	**116,729**	**115,021**	**115,394**	**110,622**	**107,273**	**98,137**	**89,851**	**80,773**	**81,159**	**80,817**

Submission	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2006 April	83,557	85,947	84,031	84,115	83,786	81,046	83,803	80,815	83,268	83,112	--
2006 Sept.	84,384	86,792	84,854	84,503	84,174	81,904	84,575	81,584	84,363	83,953	--
2007 April	81,143	83,377	81,397	80,783	80,976	79,091	80,964	78,817	82,224	79,620	80,574
2007 May	**79,241**	**81,399**	**79,442**	**78,976**	**79,132**	**77,340**	**79,111**	**77,054**	**80,284**	**79,204**	**80,248**

Table 10.2. *Recalculation differences of National Total GHG emission without CO_2 from LULUCF* *Note: AY =average of 1985-87 and BY=average of 1985-87 but 1995 for F-gases*

It should be noted, that the above time series are consistent only in the years 2004 and 2005, because we have not been able to do the calculation in certain categories entirely, yet.

The modifications in certain sectors are shown in the following tables (Gg CO_2eq), for the base year and for 2004:

ENERGY	Base year (1985-87)	2004	2005
2006 April	86,314	61,466	--
2006 Sept.	86,762	61,962	--
2007 April	84,717	60,499	61,780
2007 May	84,006	60,083	61,455

Table 10.3. *Recalculation differences in Energy Sector*

INDUSTRY	Base year (1985-87)	2004	2005
2006 April	10,039	5,427	--
2006 Sept.	10,440	5,770	--
2007 April	10,614	5,947	6,209
2007 May	10,614	5,947	6,209

Table 10.4. *Recalculation differences in Industry Sector*

Note: AY =average of 1985-87 and BY=average of 1985-87 but 1995 for F-gases

AGRICULTURAL	Base year (1985-87)	2004	2005
2006 April	20,009	11,182	--
2006 Sept.	20,009	11,181	--
2007 April	17,496	9,055	8,464
2007 May	17,496	9,055	8,464

Table 10.5. *Recalculation differences in Agricultural Sector*

LULUCF	Base year (1985-87)	2004	2005
2006 April	-3,613	-3,929	--
2006 Sept.	-2,736	-5,518	--
2007 April	-3,117	-4,441	-4,476
2007 May	-3,117	-4,441	-4,476

Table 10.6. *Recalculation differences in LULUCF Sector*

WASTE	Base year (1985-87)	2004	2005
2006 April	5,367	4,672	--
2006 Sept.	5,439	4,675	--
2007 April	3,070	3,754	3,942
2007 May	3,070	3,754	3,942

Table 10.7. *Recalculation differences in Waste Sector*

It reveals that due to the recalculation the emission of Agriculture and Waste sectors decreased most of all, while the emission of the Industry increased in a small compass. Concerning gases, amounts of the CH_4 and the N_2O decreased significantly.

10.2. Implications for Emission Trends

The recalculations did not affect the trends of either the gases or the sectors. The reduction of the emissions as a result of the economic regression and the subsequent modernisation was so significant that the recalculations could not change these trends.

10.3. Planned Improvements

Energy sector:

EU ETS will give opportunity to get detailed information from those establishments that emit more than 500 kt CO_2/year. These installations can calculate their emission according to measurement data. Evaluating the measurements it is possible to define new emission factors that suit better to the Hungarian conditions. Instead of IPCC default emission factors we will calculate the national emissions using more appropriate values. Besides, we will get more detailed and technology-specific information about fuel combustion in the field of energy industry and manufacturing industry and construction.

To achieve consistent time-series, recalculation of emission in road transport categories will be continued.

Agriculture sector:

In the sector of Agriculture a development project is proceeding, so on the basis of the results, we will be able to apply the TIER 2 methods in the calculation of emission from enteric fermentation and manure management of the ruminants, in the little future.

In Forest land category of the LULUCF sector recalculation may take place in the next few years if revisions of the activity data or the used factors will be conducted.