Hungarian Meteorological Service
Greenhouse Gas Inventory Division

National Inventory Report for 1985-2008

Hungary

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Prepared by:			Gábor Kis-Kovács Leader of Division
	Energy		Klára Tarczay, expert
	Industry, Solvent and Other Product Use		Edit Nagy, expert
	Agriculture		Dr. György Borka, external expert
	LULUCF	Forest land	Péter Kottek and Dr. Zoltán Somogyi, external contributors
		Cropland, Grassland	Dr. József Zsembeli, external expert Katalin Lovas, expert
	Waste		Gábor Kis-Kovács

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EXECUTIVE SUMMARY

ES.1. Background information

Pursuant to the United Nations Framework Convention on Climate Change (UNFCCC), Hungary, as a Party of the Convention, has been preparing annual inventories of greenhouse gas emissions using the IPCC methodology since 1994. The aim of a greenhouse gas (GHG) inventory is to give a complete and accurate as possible, state of the art estimation of anthropogenic emissions by sources and removal by sinks of greenhouse gases not controlled by the Montreal Protocol. In accordance with the Kyoto Protocol, the following direct greenhouse gases are taken into account: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The quality of the inventory is controlled by Hungarian and international experts regularly.

The GHG inventory is compiled by the Hungarian Meteorological Service, based on a mandate of the Minister of Environment and Water. Also other institutions and external experts are involved in the process of inventory preparation, e.g. the Hungarian Central Statistical Office, Energy Efficiency, Environment and Energy Information Agency, Research Institute for Animal Breeding and Nutrition, Karcag Research Institute of University of Debrecen, just to name a few. The participation of the Forestry Directorate of the Central Agricultural Office (CAO) together with the Forest Research Institute is now formalized by a governmental decree.

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 1985-2008. 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 National Emissions and Removal Related Trends

In 2008, total emissions of greenhouse gases in Hungary were 73.7 million tonnes carbon dioxide equivalents (excluding the LULUCF sector). This is by far the lowest value in the whole time series (1985-2008). Taking also into account the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 69.1 million tonnes CO_2 eq. in 2008. With about 7 tonnes, the Hungarian per capita emissions are below the European average.

By ratifying the Kyoto Protocol, Hungary committed to reducing its GHG emissions by 6%. Now, our emissions are 36.8% lower than in the base year (average of 1985-87). For the most part, this significant reduction was mainly a consequence of the regime change in Hungary (1989-90) which brought in its train radical decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors like energy, industry and agriculture. Then between 2005 and 2008, after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 8.5 per cent.

Emissions (excluding LULUCF) decreased by 3.4% (-2.6 million tonnes) between 2007 and 2008. In comparison with 2007, emissions in 2008 were lower in all major sectors. The highest relative reduction (-20.6%) occurred in the industrial processes sector mainly due to lower production volumes and modernization in chemical industry (-62.6%). Out of the 2.6 million tonnes reduction, chemical industry was responsible for about 1.2 million tonnes.

Further decrease of 0.9 million tonnes was mainly due to favourable changes in the fuel-mix used by the energy industries (less fossil fuel consumption).
The most important greenhouse gas is carbon dioxide accounting for 76.3% of total GHG emissions. The main source of CO_2 emissions is burning of fossil fuels for energy purposes, including transport. CO_2 emissions have decreased by 33.9% since the middle of the 80's. Methane represents 11.4% in the GHG inventory. Methane is generated mainly in waste disposal sites and animal farms, but the fugitive emissions of natural gas are also an important source. CH_4 emissions are 29.6% lower than in base year. Nitrous oxide contributes 11.0% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N_2O emissions are 57.8% lower compared to base year. The total emissions of fluorinated gases amount to 1.3%. F-gas emissions are showing a fluctuating, slightly growing tendency especially due to their applications in the cooling industry.

Table ES. 1. Base year=average of 1985-87

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	Base year	1990	1995	2000	2005	2006	2007	2008
CO_2, without LULUCF	85,024.99	72,559.68	61,436.27	58,543.15	60,970.82	59,655.71	57,882.50	56,224.66
CH_4, without LULUCF	11,892.23	11,172.40	9,237.88	9,373.77	8,801.48	8,715.31	8,554.27	8,376.84
N_2O, without LULUCF	19,260.59	14,925.44	8,643.54	9,455.46	9,765.57	9,546.71	9,070.52	8,127.98
HFCs	0.0	0.0	0.78	211.34	537.77	592.05	621.18	703.38
PFCs	268.49	270.83	166.82	211.26	209.39	1.53	2.38	2.41
SF_6	81.02	39.87	70.15	140.11	201.02	244.45	171.65	237.85
Total (excluding LULUCF)	**116,527.32**	**98,968.22**	**79,555.43**	**77,935.09**	**80,486.06**	**78,755.76**	**76,302.49**	**73,673.12**

ES.3. Overview of Source and Sink Category Emission Estimates and Trends

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	Base year	1990	1995	2000	2005	2006	2007	2008
Energy	82,455.28	70,184.85	60,529.01	57,510.11	59,507.90	58,433.51	56,353.09	55,225.09
Industrial Processes	11,401.55	9,219.95	5,716.44	6,569.34	7,338.36	6,714.69	6,296.93	5,001.77
Solvent and Other Pr. Use	284.54	226.27	205.16	213.71	366.33	334.66	366.15	406.30
Agriculture	19,413.91	16,046.38	9,593.43	9,934.07	9,418.26	9,438.76	9,502.16	9,314.60
LULUCF	-2,186.72	-2,886.45	-6,776.27	-1,276.25	-4,628.38	-2,641.61	-2,938.78	-4,574.76
Waste	2,972.03	3,290.77	3,511.39	3,707.85	3,855.22	3,834.14	3,784.16	3,725.37
Total (including LULUCF)	**114,340.60**	**96,081.76**	**72,779.17**	**76,658.84**	**75,857.68**	**76,114.15**	**73,363.71**	**69,098.36**

By far, the biggest emitting sector was the energy sector contributing 75.0% to the total GHG emission in 2008. Agriculture was the second largest sector with 12.6% while emissions from industrial processes (with solvent and other product use) accounted for 7.3% and the waste sector contributed 5.1%. Compared to the base year, emissions were significantly reduced in the energy (-33.0%), agriculture (-52.0%), and industrial processes (-56.1%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+25.3%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.

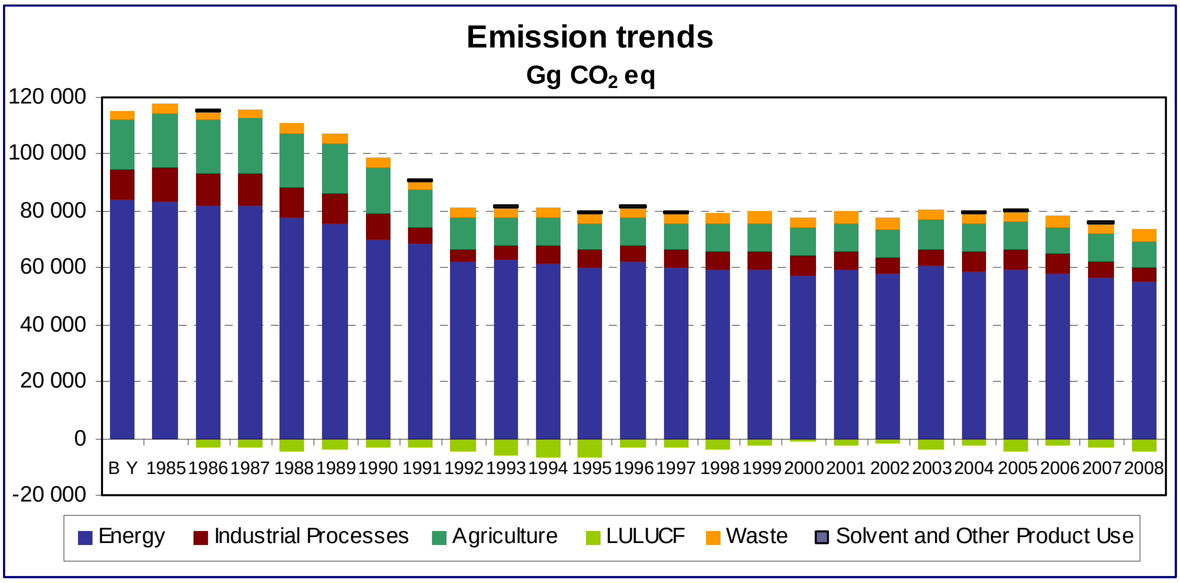


Figure ES. 1. *Change in greenhouse gas emissions from base year (1985-2008)*
Note: BY=average of 1985-87 but 1995 for F-gases

The *energy sector* was responsible for 75.0% of total GHG emissions in 2008. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.3% to sectoral emission. Considering fuel use, gases had the highest proportion (51.8%), liquids and solids represented 26.3% and 14.9%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 6.2%. The most important subsector was energy industries with a proportion of 35.6%, followed by other sectors (25.0%) and transport (23.3%). Fugitive emissions from fuels played only a small role with 3.9%. The most dynamically increasing category was transport which had 65.7% higher total emission in 2008 compared to the base year.
The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation which caused sudden decrease in energy demand. Besides, ongoing changes in the fuel-structure, i.e. solid fuel as the most important source in the 80's had been replaced by natural gas, led to further decrease of total emission.
Overall emissions from the energy sector decreased by 2.0% between 2007 and 2008. Although slightly more electricity was generated in domestic power stations, the lower share of fossil fuels and the higher share of nuclear and renewable energy for electricity and heat production resulted in 4.3% decrease in emissions from energy industries. The growth in GHG emissions from transport was quite moderate (0.4%) after a more than 80% increase between 1995 and 2007. The almost six-fold rise in biofuel use could nearly meet the increased energy demand of transport in 2008. The tertiary sector used some 8% less energy, and the residentials' energy consumption remained below expectations. Taking into account the growing energy prices (e.g. the price of pipelined gas increased by 70% in the last two years), energy-saving measures must have contributed to the trend of emissions.

In 2008, *agriculture* was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH_4 and N_2O gases: 83.0 percent of total N_2O emissions were generated in agriculture in 2008. Emissions from agriculture decreased by 52.0% over the period of 1985-2008. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by about 35 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 16.7% to its present share of 12.6%.
Between 1996 and 2008, agricultural emissions showed a slightly decreasing trend with fluctuations up to ±6%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers

increased by about 60% which caused growing nitrous-oxide emissions from agricultural soils.
Agricultural emissions fell by 2.0 between 2007 and 2008. This reduction was mainly driven by the 9.3% decrease in swine population due to high forage prices in 2008. Besides, rising fertilizer prices led to 8% lower fertilizer use and thus lower N_2O emissions from agricultural soils which could not be offset by increased emissions from crop residues.

The *industrial processes* sector was the third largest contributing 6.8% to total GHG emissions in 2008. (Solvent and other product use added further 0.6% to total emissions.) The most important greenhouse gas was CO_2, contributing 80.7% to total sectoral GHG emissions, followed by F-gases with 18.9%. Within this sector, 45.4% of the emissions came from mineral products, followed by 18.9% from consumption of halocarbons and SF_6 and 13.2% from chemical industry. Process related industrial emissions decreased by 56.1% between base year and 2008, and by 31.8% between 2005 and 2008.
The key driver of the 20.6% reduction between 2007 and 2008 was the chemical industry. Ammonia and nitric acid production decreased by 26%, which was reflected also in the lower energy use of chemical industry, and on top of this, the new nitric acid plant, thanks to a JI project, almost abolished the factory's nitrous oxide emission in the magnitude of one million tonnes CO_2 equivalent. Besides, brick production decreased, and the cement industry was able to lower its emissions by using more additives to lower the fraction of clinker in the cement.
Although emissions of F-gases represent only 1.3% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission increased tenfold.

The *waste sector* represented 5.1% of total national GHG emissions in 2008. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+25.3%). However, the growth of emissions seemed to be stopping in recent years, moreover a reduction of 3.4% could be observed between 2005 and 2008. In all the years, the largest category was solid waste disposal on land, representing 78.7% in 2008, followed by wastewater handling (19.5%) and waste incineration (1.8%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade.

In the *Land Use Land-Use Change and Forestry* sector, using the currently available data, carbon uptake of the forests living biomass, non-CO_2 emissions from burning of slash on-site, and for the last couple of years, forest wildfires are reported. Overall, the sector is a sink of carbon because of the huge amount of carbon uptake of forests, due to continuous afforestation efforts and sustainable forest management. In the inventory period, the forest area increased by 350,000 hectares, and the amount of the current annual increment exceeded the annual harvest in all years. The complex dynamics of the land use and land-use changes lead to highly fluctuating estimates of sectoral removals. Our estimates indicate an average annual 3.5 million tonnes removal with fluctuations in the range of ± 96 percent in the inventory period.
In 2008 the LULUCF sector accounted for 4.6 million tonnes carbon-dioxide removals. The removals of forests amounted to 4.9 million tonnes, while the living biomass of orchards and vineyards are a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. In 2008 the emission of the living biomass of vineyards and orchards accounted for net 0.17 million tonnes CO_2.
Our mineral soils used for agricultural purposes, similarly to the results of the last years, are a minor source of carbon, although there are some favourable processes which aim at the increase of the soil carbon content e.g. the abandonment of croplands and the conventional tillage method replacement by new soil conservation tillage methods.

ES.4. Indirect Greenhouse Gases and SO_2

NO_X, CO and NMVOC gases are referred to as indirect gases because they (together with SO_2) influence atmospheric warming indirectly, via secondary effects. Nitrogen oxides, carbon monoxide and (non methane) volatile organic compounds are precursor of ozone which is itself a naturally occurring greenhouse gas. Sulphur dioxide can contribute to formation of aerosols that scatter some of the solar radiation back into space. Calculation of the emissions of these gases was required by the IPCC 1996 Revised Guidelines and the CRF software 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 software 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).

The following table shows the main trends in emissions:

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

Indirect gases	*1985*	*1986*	*1987*	*1988*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
NO_X, Gg	*262.5*	*264.2*	*264.9*	*257.8*	*238*	*203.1*	*183.3*	*184*	*187.4*	*190.07*	*195.81*
CO, Gg	*931.1*	--	--	*963.1*	*997*	*913.4*	*835.8*	*796.1*	*774.29*	*761.29*	*726.87*
NMVOC, Gg	*232*	*263*	*228*	*215*	*205*	*149.6*	*141.8*	*149*	*142.4*	*150.3*	*150.1*
SO_2, Gg	*1403.6*	*1361.8*	*1285.3*	*1218*	*1010*	*913*	*827.3*	*757.3*	*741*	*704.96*	*673.23*
	1997	*1998*	2000	2001	2002	2003	2004	2005	2006	2007	2008
NO_X, Gg	*199.5*	*202.62*	185.08	183.21	182.94	210.70	185.26	203.15	202.44	185.43	170.58
CO, Gg	*733.36*	*736.93*	592.66	578.54	573.55	599.82	583.37	588.20	594.31	576.70	570.34
NMVOC, Gg	*145.4*	*140.6*	166.01	162.25	160.15	169.01	157.04	176.23	186.71	167.68	169.65
SO_2, Gg	*658.51*	*591.79*	488.96	403.89	364.90	347.83	248.78	146.65	123.11	98.59	106.73

The substantial reduction in sulphur dioxide emissions (-90%) is attributable to the decreased use and lower 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 a consequence of decreased fuel uses. NO_X and NMVOC emissions showed 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, inventories have been compiled annually as required. According to the Convention, the year 1990 considered as general reference level was not adequate for Hungary 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. Instead of 1990, the average of years 1985, 1986 and 1987 (hereinafter referred to as ”base year”) 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 replacements for ozone depleting chlorofluorocarbons.) Hungary has chosen the year 1995 as the base year for fluoride gases.

The process of inventory preparation has been improved year by year. The inventory teams did their best to meet the changing and growing requirements. Particular emphasis was placed on determining the specific emission factors for Hungary.

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. The fixed base year emission of Hungary is 115,397.149 Gg. Hungary’s assigned amount is calculated as 542,366,600 tonnes CO_2 equivalent.

The regional effects of the global climate change can clearly be 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. 2008 was the 3th warmest year since 1901 (the homogenized, interpolated dataset is available from the beginning of the 20th century) in Hungary (Fig. 1.1). The annual mean temperature was 11.5℃ that was 1.5℃ warmer than the annual averag e (mean of 1971-2000 period). The five warmest years occurred also at the end of the period. The monthly temperature exceeded the average in every month, except September. (Fig. 1.2.).

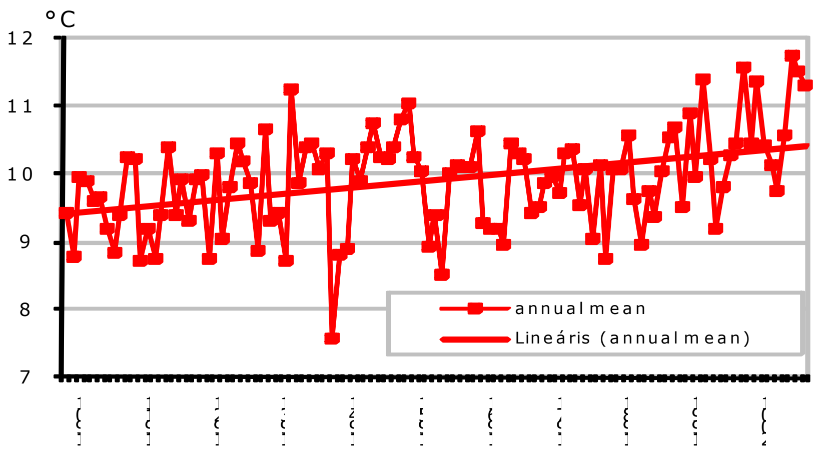


Figure 1.1. Annual mean temperature (℃) in the period 1901-20 09 in Hungary

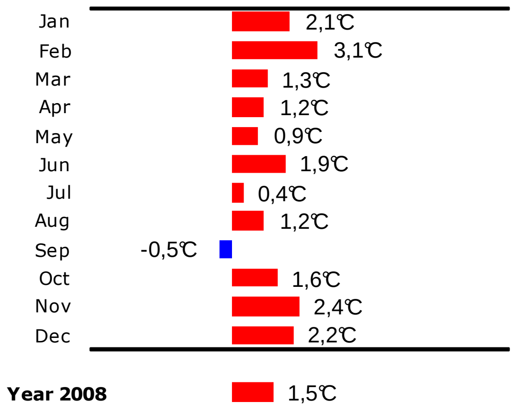


Figure 1.2. Anomalies (compared to 1971-2000 mean)of the countrywide monthly mean temperatures in 2008 in Hungary (ºC)

The yearly total precipitation in 2008 (579 mm) was around the average. The exponential trend fitted to the 109 year-long data series shows moderate declining (Fig. 1.3.). The sum of countrywide amount set was out 102% of the long time average. Monthly amounts and anomalies varied heavily within the year (Fig 1.4.).

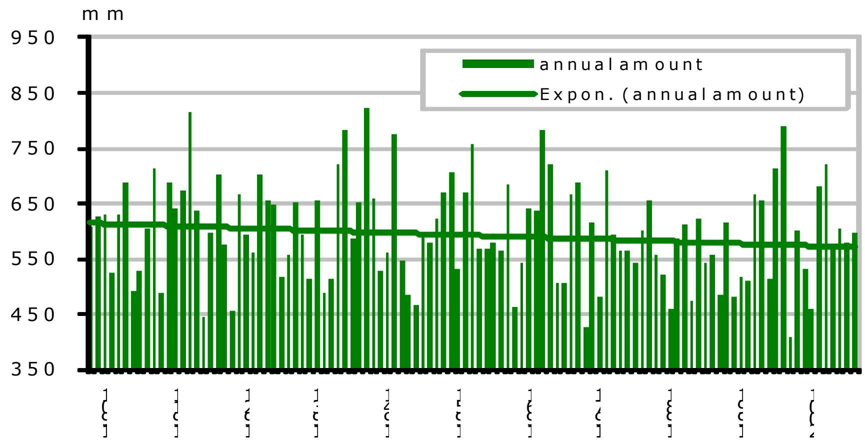


Figure 1.3. Annual precipitation sum (mm) in the period 1901-2009 in Hungary

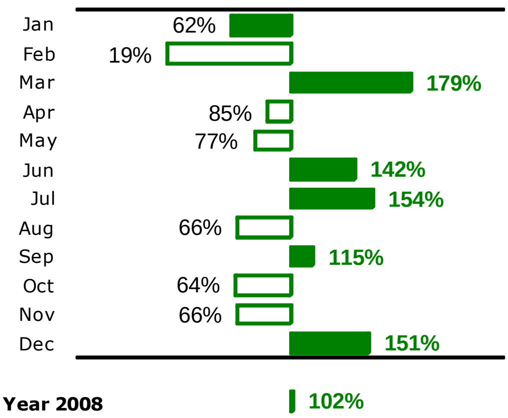


Figure 1.4. Monthly precipitation averages (%) in 2008
compared to the reference period (1971-2000 mean) in Hungary

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 Policy Unit (formerly Climate Change and Energy Department) administers this responsibility by supervising the national system.

At the end of 2006, 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, compiles 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.

The above was confirmed also in July 2009 in an official letter of the NFP for the UNFCCC, Dr. Tibor Faragó, as well. He stated that all the GHG inventory related tasks both in the context of the Convention and its Kyoto Protocol will be supervised and fulfilled by the Climate Policy Unit in close cooperation with a unit established at the Met. Service dedicated just to this task. The GHG focal point on Mr. Faragó's behalf in the ministry is Ms. Mónika Gottfried, NFP/GHG and at the implementation level the key responsible person remains Mr. Gábor Kis-Kovács, GHG Inventory Focal Point. The contact information is the following:

- Ms. Mónika Gottfried, NFP/GHG, Hungary, Ministry of Environment and Water (Környezetvédelmi és Vízügyi Minisztérium), Fő utca 44-50 / H-1011 Budapest, Hungary, gottfried@mail.kvvm.hu
- Dr/Ms. Erika Hasznos, director, Climate Policy Unit, Ministry of Environment and Water (Környezetvédelmi és Vízügyi Minisztérium), Fő utca 44-50 / H-1011 Budapest, Hungary, hasznose@mail.kvvm.hu
- Mr. Gábor Kis-Kovács, GHG Inventory Focal Point, Hungarian Meteorological Service (OMSZ), GHG Division, Kitaibel Pál utca 1 / H-1024 Budapest, Hungary, kiskovacs.g@met.hu

At the very end of 2009, a new government decree on data provision relating to GHG emissions was put into force. This decree confirmed the minister's leading role in the national system on the one hand, and the designation of the Hungarian Meteorological Service as the compiler institute on the other. As a new element, the participation of the Forestry Directorate of the Central Agricultural Office (CAO) together with the Forest Research Institute is now formalized by this decree. These two institutes are responsible for the forestry part of the LULUCF sector and for the supplementary reporting on LULUCF activities under Articles 3.3 and 3.4 of the Kyoto Protocol by way of making recommendations to HMS of the content of the inventory.

The Hungarian Meteorological Service is a central office under the control 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. The GHG Inventory Division is reporting directly to the president of the Service.

The GHG division of the Hungarian Meteorological Service 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 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 the different sectors and also a QA/QC coordinator and an archive

manager were nominated.
Some parts of the inventory (mainly energy, industrial processes and waste) are prepared by the experts of the GHG division themselves; the calculations of other sectors are made by external experts / institutions on contractual basis as follows. The agriculture sector of the inventory has been prepared by the Research Institute for Animal Breeding and Nutrition for several years. This institute collects the data, chooses the calculation method, prepares the inventory in CRF format and sends it to the inventory compiler in xml format. For the calculation of soil C stock changes Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) was contracted like in the last two years. 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
Inventory coordination and compilation	OMSZ GHG division	• Provision of work plan • Contracting consultants • Inventory preparation of Energy, Industry and Waste sector • Completion of CRF and NIR • Archiving • Coordinating QA/QC activities • Reporting to UNFCCC secretariat
Inventory preparation of Forestry and LULUCF activities under the KP. (by law)	Central Agricultural Office (Forestry Directorate) Forest Research Institute	• Data collection, choice of methods and EFs, inventory preparation
Inventory preparation of Agriculture sector	Research Institute for Animal Breeding and Nutrition	• Data collection, choice of method, emission calculation • Inventory preparation
Inventory preparation of Soil C stock changes	Karcag Research Institute of University of Debrecen	• Data collection, choice of methods and EFs, inventory preparation

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.
As a general method of preparing the inventory, the procedures described in the IPCC Guidelines are applied and the latest CRF Reporter software is used. Usually, the sectoral experts are responsible for the choice of methods and emission factors. According to the recommendations of the IPCC Guidelines, the calculation methods are chosen by taking into account the technologies available in Hungary whenever possible. The calculation of emissions occurs basically by using the formula: AD x EF, where the activity data (AD) can be raw material or product or energy use etc. Part of the available data (e.g. production data) can directly be 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. The default emission factors (EF) are being gradually replaced by country-specific emission factors characteristic of domestic technologies. Efforts are made to use the highest possible Tier method, especially in case of key categories. 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 software.
Recalculation of some data-series of the inventory can be justified by several reasons. Just to name a few, QA/QC procedures, ERT recommendations, changing for higher Tier methodologies can lead to a recalculation. As a basic rule, whenever new information emerges that improves the quality or accuracy of the emission data, the emissions are recalculated. Recalculations are always documented in the relevant chapter of the national inventory report.
As described above, the GHG Division at the Hungarian Meteorological Service compiles the GHG inventory. In other words, the compiler institute makes a recommendation of the content of the inventory to the Minister of Environment and Water. Following the regulations of the above-mentioned new government decree on data provision relating to GHG emissions, official submission can only be made after ministerial approval of the recommended inventory. In practice, the GHG inventory is submitted by the Hungarian Meteorological Service.

1.3.1. Data collection, processing and storage

Data collection happens in several ways and throughout the whole yearly cycle of the inventory preparation. Sector specialists of the core team (or external experts on contractual basis) are making the data inquiry and collection. 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 and the Environmental Report of Hungary published by the Hungarian Central Statistical Office (HCSO) and the Energy Statistical Yearbook published by the Energy Efficiency, Environment and Energy Information Agency. Since the use of ETS data has several advantages, the inventory team was granted access to the verified emissions database held by the National Inspectorate for Environment, Nature and Water. In addition to statistical data, contacts were established with the representatives of a number of major emitting sectors. Moreover, information from the web sites of international associations (e.g., International Iron and Steel Institute, IISI) is used as well. For the calculation of fluoride gas emissions, import data from the Customs Office and Police were used together with data obtained directly from companies importing and using fluorinated gases and information from cooling industry associations.
The Act LX of 2007 on the implementation framework of the UN Framework Convention on Climate Change and the Kyoto Protocol thereof 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 gives a permanent status to the system. Relevant paragraphs for data collection are the following: “The state authorities having disposal of the data necessary to operate the National Registration System and the organizations emitting at least 100 tons of carbon dioxide equivalent per year shall provide these data for the National Registration System in accordance with the provisions of a separate legal instrument.” “The data (…) necessary to fulfill international data supply shall be provided for the National Registration System irrespective of the fact that they are qualified as individual data pursuant to the relevant provision of Act XLVI of 1993 on statistics.” This separate legal instrument, the above-mentioned government decree on data provision relating to GHG emissions prescribes compulsory data provision for GHG inventory purposes for numerous governmental bodies and emitters.
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)
- Forestry statistics – Central Agricultural Office Forest Directorate
- 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. 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. 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, the nominated archive manager 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.

1.4. Brief general description of methodologies and data sources used

The IPCC Guidelines provide methodologies for estimating emissions and removals of greenhouse gases. However, the basic idea is not greenhouse gas specific, the same approach is used for other pollutants, and other emission inventories, as well (e.g. see the EMEP/EEA air pollutant emission inventory guidebook). The basic equation is as simple as this:

$$Emission = AD \times EF,$$

where AD stands for activity data which represents some human activity (e.g. fuel use, industrial production, animal population, dwellings supplied with public sewerage, area of vineyard abandonment), whereas EF is the emission factor that quantifies the emission (or

removal) per unit of activity. For example, in energy industry, which is the most important source category, emission factors for combusting natural gas or lignite are 56.1 t CO2 / TJ and 108.3 t CO2 / TJ, respectively; the importance of the mix of fuels used to produce energy becomes apparent at a glance.
Emission factors are usually dependent on several other factors, used technologies etc. which leads us to the concept of tiers. A tier represents a level of methodological complexity. In the Guidelines usually three tiers are provided. Tier 1 is the basic method, where activity data are usually aggregated national statistics and the emission factors are default values representing typical process conditions. Higher tier methodologies are more demanding in terms of complexity and data requirements as they require country-specific information on the used technologies, facility level data whenever possible, or use of complex models. For key categories, i.e. categories that have a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals, it is required to apply higher tier methods. Accordingly, the compilers of the Hungarian inventory aim at taking into account the technologies available in Hungary to the extent possible. For example, the emission trading system of the European Union makes possible to have access to facility level activity and verified emission data.
Although this basic equation can widely be used, in some source categories other approaches are used. For example, mass balance method is used for estimating the change in carbon content of living biomass in forests, or in case of solid waste disposal sites, a calculation method is applied which assumes that the degradable organic component in waste decays slowly throughout a few decades.
To ensure that the national inventory fulfils its main purpose, namely monitoring the country's compliance with its commitments, it has to meet certain quality standards, in other words it has to be accurate, complete, consistent, comparable and transparent (ACCCT). The first two requirements need no special explanation: an inventory is accurate, if it has no systematic bias towards under- or overestimations, whereas a complete inventory covers all relevant sources and sinks, and gases within the borders of the country. The next two criterions are closely linked to the requirements of the UNFCCC. Consistency ensures that the trends in the times-series of the inventory reflect real differences in emissions, and not caused by any methodological changes. National greenhouse gas inventories of all countries shall be comparable, therefore the submitted information shall be compiled in accordance with the UNFCCC reporting guidelines and the IPCC guidelines and good practice guidance.
More detailed source specific information on used data and methodologies can be found in Chapters 3-9 in this inventory report.

1.5. Key source categories

Key sources have been identified using Tier 1 methodology in accordance with the guidance of the GPG for several years. This year more detailed categories (with LULUCF) were taken in key category analysis in line with the requirements of the European Union. The analysis with Tier 2 methodology was also made following the categorization of previous years. The required uncertainty values were determined on the basis of the GPG but estimates of data supplier institutions and experts were used as well. 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). All greenhouse gases and sectors were taken into account for both analyses. In order to identify the key categories, both the LEVEL and the TREND analysis were performed.
Using the concept of "Combined uncertainty" from the Tier 2 methodology, LEVEL 2 and TREND 2 identified 12 and 14 key sources, respectively.

Level 2 key categories			Trend 2 key categories		
1. A.	Stationary Combustion - Gas	CO_2	1. A.	Stationary Combustion - Gas	CO_2
1. A.	Stationary Combustion - Coal	CO_2	1. A.	Stationary Combustion - Coal	CO_2
1. A. 3.	Mobile Combustion	N_2O	1. A.	Stationary Combustion - Oil	CO_2
1. A. 3. B.	Mobile Combustion - Road	CO_2	1. A. 3.	Mobile Combustion	N_2O
1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH_4	1. A. 3. B.	Mobile Combustion - Road	CO_2
4. A	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH_4
4. B	CH_4 Emissions from Manure Management	CH_4	2. F. 7.	SF_6 Emissions from Electrical Equipment	SF_6
4. B.	N_2O Emissions from Manure Management	N_2O	4. A	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4
4. D. 1.	Direct N_2O Emissions from Agricultural Soils	N_2O	4. B	CH_4 Emissions from Manure Management	CH_4
4. D. 3.	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O	4. B	N_2O Emissions from Manure Management	N_2O
6. A.	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	4. D. 1.	Direct N_2O Emissions from Agricultural Soils	N_2O
6. B.	Emissions from Wastewater Handling	N_2O	4. D. 3.	Indirect N_2O Emissions from Nitrogen Used in Agriculture	N_2O
			6. A.	CH_4 Emissions from Solid Waste Disposal Sites	CH_4
			6. B.	Emissions from Wastewater Handling	N_2O

Results of key category calculation with LULUCF are summarized in *Table 1.1*. The LEVEL and TREND methods found 45 and 46 key categories, respectively.

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**
1. Energy				
Stationary Combustion - Public electricity and heat production	CO_2	Yes	L, T	
Stationary Combustion - Public electricity and heat production	CH_4	No		
Stationary Combustion - Public electricity and heat production	N_2O	No		
Stationary Combustion - Petroleum refining	CO_2	Yes	L, T	
Stationary Combustion - Petroleum refining	CH_4	No		
Stationary Combustion - Petroleum refining	N_2O	No		
Stationary Combustion - Manuf. of solid fuels and other energy industries	CO_2	No		
Stationary Combustion - Manuf. of solid fuels and other energy industries	CH_4	No		
Stationary Combustion - Manuf. of solid fuels and other energy industries	N_2O	No		
Stationary Combustion - Iron and steel	CO_2	Yes	L, T	
Stationary Combustion - Iron and steel	CH_4	No		
Stationary Combustion - Iron and steel	N_2O	No		

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**
Stationary Combustion - Non-ferrous metals	CO_2	Yes	L, T	
Stationary Combustion - Non-ferrous metals	CH_4	No		
Stationary Combustion - Non-ferrous metals	N_2O	No		
Stationary Combustion - Chemicals	CO_2	Yes	L, T	
Stationary Combustion - Chemicals	CH_4	No		
Stationary Combustion - Chemicals	N_2O	No		
Stationary Combustion - Pulp, paper and print	CO_2	No		
Stationary Combustion - Pulp, paper and print	CH_4	No		
Stationary Combustion - Pulp, paper and print	N_2O	No		
Stationary Combustion - Food processing, beverages and tobacco	CO_2	Yes	L, T	
Stationary Combustion - Food processing, beverages and tobacco	CH_4	No		
Stationary Combustion - Food processing, beverages and tobacco	N_2O	No		
Stationary Combustion - Other	CO_2	Yes	L, T	
Stationary Combustion - Other	CH_4	No		
Stationary Combustion - Other	N_2O	No		
Mobile combustion - Civil aviation	CO_2	No		IE,NO
Mobile combustion - Civil aviation	CH_4	No		IE,NO
Mobile combustion - Civil aviation	N_2O	No		IE,NO
Mobile combustion - Road transportation	CO_2	Yes	L, T	
Mobile combustion - Road transportation	CH_4	No		
Mobile combustion - Road transportation	N_2O	Yes	L, T	
Mobile combustion - Railways	CO_2	Yes	T	
Mobile combustion - Railways	CH_4	No		
Mobile combustion - Railways	N_2O	No		
Mobile combustion - Navigation	CO_2	No		
Mobile combustion - Navigation	CH_4	No		
Mobile combustion - Navigation	N_2O	No		
Stationary Combustion - Commercial/institutional	CO_2	Yes	L, T	
Stationary Combustion - Commercial/institutional	CH_4	No		
Stationary Combustion - Commercial/institutional	N_2O	No		
Stationary Combustion - Residential	CO_2	Yes	L, T	
Stationary Combustion - Residential	CH_4	No		
Stationary Combustion - Residential	N_2O	No		
Stationary Combustion - Agriculture/Forestry/Fisheries	CO_2	Yes	L, T	
Stationary Combustion - Agriculture/Forestry/Fisheries	CH_4	No		
Stationary Combustion - Agriculture/Forestry/Fisheries	N_2O	No		
Fugitive Emissions from Fuels - Solid Fuels	CO_2	No		IE,NA,NO

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**
Fugitive Emissions from Fuels - Solid Fuels	CH_4	Yes	T	
Fugitive Emissions from Fuels - Solid Fuels	N_2O	No		NA, NO
Fugitive Emissions from Fuels - Oil and Natural Gas	CO_2	No		
Fugitive Emissions from Fuels - Oil and Natural Gas	CH_4	Yes	L, T	
Fugitive Emissions from Fuels - Oil and Natural Gas	N_2O	No		
2. Industrial Processes				
Mineral Products - Cement production	CO_2	Yes	L	
Mineral Products - Lime production	CO_2	Yes	L	
Mineral Products - Limestone and dolomite use	CO_2	Yes	L	
Mineral Products - Asphalt roofing	CO_2	No		NA
Mineral Products - Road paving with asphalt	CO_2	No		NA
Mineral Products - Other	CO_2	Yes	L	
Mineral Products - Other	CH_4	No		IE, NA
Mineral Products - Other	N_2O	No		IE, NA
Chemical Industry - Ammonia production	CO_2	Yes	L, T	
Chemical Industry - Ammonia production	CH_4	No		NO
Chemical Industry - Ammonia production	N_2O	No		NO
Chemical Industry - Nitric acid production	CO_2	No		
Chemical Industry - Nitric acid production	N_2O	Yes	T	
Chemical Industry - Other	CO_2	No		
Chemical Industry - Other	CH_4	No		NO
Chemical Industry - Other	N_2O	No		NO
Metal Production - Iron and steel production	CO_2	Yes	L	
Metal Production - Iron and steel production	CH_4	No		IE, NA
Metal Production - Ferroalloys production	CO_2	No		NO
Metal Production - Ferroalloys production	CH_4	No		NO
Metal Production - Aluminium production	CO_2	No		NO
Metal Production - Aluminium production	CH_4	No		NO
Metal Production - Aluminium production	PFCs	No		NO
Other Production	CO_2	No		
Production of Halocarbons and SF_6	HFCs	No		NA, NO
Production of Halocarbons and SF_6	PFCs	No		NA
Production of Halocarbons and SF_6	SF_6	No		NA, NO
Consumption of Halocarbons and SF_6 - Refrigeration and air conditioning equipment	HFCs	Yes	L, T	
Consumption of Halocarbons and SF_6 - Refrigeration and air conditioning equipment	PFCs	No		
Consumption of Halocarbons and SF_6 - Refrigeration and air conditioning equipment	SF_6	No		NO

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**
Consumption of Halocarbons and SF_6 - Foam blowing	HFCs	No		
Consumption of Halocarbons and SF_6 - Foam blowing	PFCs	No		NO
Consumption of Halocarbons and SF_6 - Foam blowing	SF_6	No		NO
Consumption of Halocarbons and SF_6 - Aerosols	HFCs	No		
Consumption of Halocarbons and SF_6 - Aerosols	PFCs	No		NO
Consumption of Halocarbons and SF_6 - Aerosols	SF_6	No		NO
Consumption of Halocarbons and SF_6 - Electrical equipment	HFCs	No		NO
Consumption of Halocarbons and SF_6 - Electrical equipment	PFCs	No		NO
Consumption of Halocarbons and SF_6 - Electrical equipment	SF_6	No		
Consumption of Halocarbons and SF_6 - Other	HFCs	No		NA
Consumption of Halocarbons and SF_6 - Other	PFCs	No		NA
Consumption of Halocarbons and SF_6 - Other	SF_6	No		
Feedstocks and non-energy use of fuels	CO_2	Yes	L, T	
3. Solvent and Other Product Use				
Solvent and Other Product Use	CO_2	No		
Solvent and Other Product Use	N_2O	Yes	L, T	
4. Agriculture				
Enteric Fermentation	CH_4	Yes	L, T	
Manure Management	CH_4	Yes	L, T	
Manure Management	N_2O	Yes	L, T	
Rice Cultivation	CH_4	No		
Agricultural Soils - Direct soil emissions	CH_4	No		NO
Agricultural Soils - Direct soil emissions	N_2O	Yes	L, T	
Agricultural Soils - Pasture, range and paddock manure	N_2O	No		
Agricultural Soils - Indirect emissions	CH_4	No		NO
Agricultural Soils - Indirect emissions	N_2O	Yes	L, T	
Field Burning of Agricultural Residues	CH_4	No		NA, NO
Field Burning of Agricultural Residues	N_2O	No		NA, NO
5. Land Use. Land-Use Change and Forestry				
Forest Land - remaining	CO_2	Yes	L, T	
Forest Land - remaining	CH_4	No		
Forest Land - remaining	N_2O	No		
Forest Land - converted to	CO_2	No		
Forest Land - converted to	CH_4	No		NE, NO
Forest Land - converted to	N_2O	No		NE, NO
Cropland - remaining	CO_2	Yes	T	

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**
Cropland - remaining	CH_4	No		IE, NE
Cropland - remaining	N_2O	No		IE, NE
Cropland - converted to	CO_2	Yes	L, T	
Cropland - converted to	CH_4	No		NO
Cropland - converted to	N_2O	No		NE, NO
Grassland - remaining	CO_2	Yes	L, T	
Grassland - remaining	CH_4	No		NE, NO
Grassland - remaining	N_2O	No		NE, NO
Grassland - converted to	CO_2	No	T	
Grassland - converted to	CH_4	No		NO
Grassland - converted to	N_2O	No		NO
Other Land - converted to	CO_2	No		
6. Waste				
Solid Waste Disposal on Land	CO_2	No		NA, NO
Solid Waste Disposal on Land	CH_4	Yes	L, T	
Waste-water Handling	CH_4	Yes	L	
Waste-water Handling	N_2O	No		
Waste Incineration	CO_2	No		
Waste Incineration	CH_4	No		
Waste Incineration	N_2O	No		

1.6. QA/QC information

The national system has to ensure high quality of the inventory, i.e. to ensure that the inventory is transparent, consistent, comparable, complete and accurate. These principles guide the internal expert team that maintains the system. 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; In 2009 a new ISO document was introduced to enable the documentation of sector specific quality checks. This document includes a compulsory check list, summary of

results of checks, suggestions for corrective actions similarly to the example given in Annex 6A of the 2006 Guidelines. 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, and regulates the documentation and archiving activities. Our 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 are to 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;
- Reviews.
    - Internal ISO audits are conducted every year. The Met. Service passed an in-depth ISO audit end of January 2009.
    - Two peer-reviews are planned in 2010: one for the industrial processes sector (postponed from last year), the other for the energy sector.
    - The recommendations of the latest centralized review by the expert review team of the UNFCCC will be taken into consideration as much as possible.
- Checking the results of the EU's internal review for the EU15, and analyze its relevance for Hungary.
- Checking the differences in activity data to increase the consistency between different emission databases, especially the GHG inventory, LRTAP inventory, ETS data, NAMEA data, and the E-PRTR data.
- Incorporation of ETS data in broader extent for revision of the used EFs and for better sectoral allocation of emissions
- Development plan. Based on the outcome of all reviews and own experience, a development plan has to be made in order to further improve the system.
- R+D projects. The Hungarian Meteorological Service funds research and development projects for the improvement of the inventory whenever possible.
- Training plan.

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 favorably in the end of March 2007; and our ISO certification has been renewed in January 2009. Therefore we can claim that the GHG inventory is subject to ISO 9001:2008.

Other QA/QC activities

Besides ISO requirements, other QA/QC activities are carried out, as well. For every sector of the inventory, there is a responsible person within the core team in the Met. Service. These sectoral responsibilities are laid down in the yearly QA/QC plan. Especially in case of external experts, this responsible member of our team conducts several quality checks on the provided calculations. Moreover, this exercise can be regarded as an interactive process throughout the whole inventory cycle, since the used methodologies, early results are discussed during the process of the emission/removal calculations. This QC procedure also led to a few recalculations. 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, new and previous estimates are compared every time. Data entry into the database is checked many times by a second person. If possible, activity data from different data sources are compared and thus verified. In response to our request, several data suppliers made declarations as regards quality assurance systems in

place during the collection of the data. Nevertheless, 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 key source categories. In a number of cases, the level of uncertainty was also characterized 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 characterized as follows:

The CO_2 calculation has the highest reliability and has a weight of 76.3% in the total emission (in CO_2eq.). The least reliable is N_2O calculation representing 11.0%. CH_4, which has a medium reliability, has a similar proportion (11.4%). Fluoride gases are irrelevant here because their contribution to the total emission in only 1.3%. Accordingly, the calculated uncertainties of the emissions of different gases are as follows (more details in *Table A7-3* in the Annexes):

CO_2	3.6%
CH_4	18.2%
N_2O	73.7%

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 2008) is 8.8% and the uncertainty introduced in trend in national emissions is 2.3%.

1.8. Completeness

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2008. All relevant gases, sectors and categories are included. The inventory is complete in terms of geographic coverage. The notation keys are used throughout the tables. However, some of the time-series are subject to ongoing revisions, especially in the LULUCF, cement production and wastewater categories, therefore the time-series are not fully consistent and some explanations connected to the notation keys are missing. For the Wastewater category more precise activity data are expected during 2010.

2. TRENDS IN GREENHOUSE GAS EMISSIONS

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, our country committed to reducing 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. Description and interpretation of emission trends for aggregated greenhouse gas emissions

The trends of the total greenhouse gas emissions may be assessed on the basis of the GWP. The table below shows the time series of net and gross emissions:

Table 2.2.1. *Total GHG emissions (including and excluding LULUCF)*

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	BY fixed	1990	1995	2000	2005	2006	2007	2008
Total (including LULUCF)	112,661	96,081	72,779	76,658	75,857	76,114	73,363	69,098
Total (excluding LULUCF)	115,397	98,968	79,555	77,935	80,486	78,755	76,302	73,673

BY=average of 1985-87 (1995 for F-gases) as fixed in 2007.

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.

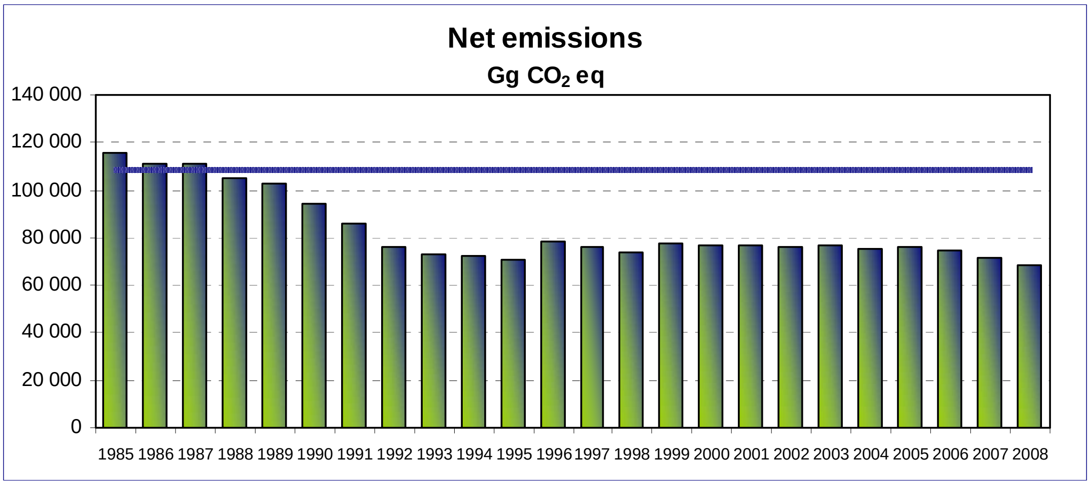


Figure 2.1. *Total emission (including net CO_2 from LULUCF) between 1985 and 2008*

Compared to the base year, emissions were significantly reduced in energy (-33.0%), agriculture (-52.0%), and industrial processes (-56.1%) sectors. In contrast, emissions in waste sector have increased since 1985 (+25.3%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.
To better understand the Hungarian emission trends, the time interval of the inventory should be split into three periods with different emission relevant economic processes in the background. The first period (1985-95) would be the years of the regime change in Hungary, whereas in the second period (1995-2006) the rules of the market economy became decisive. The second period can also be characterized by the decoupling of GDP growth

from the GHG emission trend which is undoubtedly an important development. By 1999, the GDP reached the pre-1990 level; however, emission levels remained significantly below the levels of the preceding years. Thus, the emissions per GDP are decreasing.

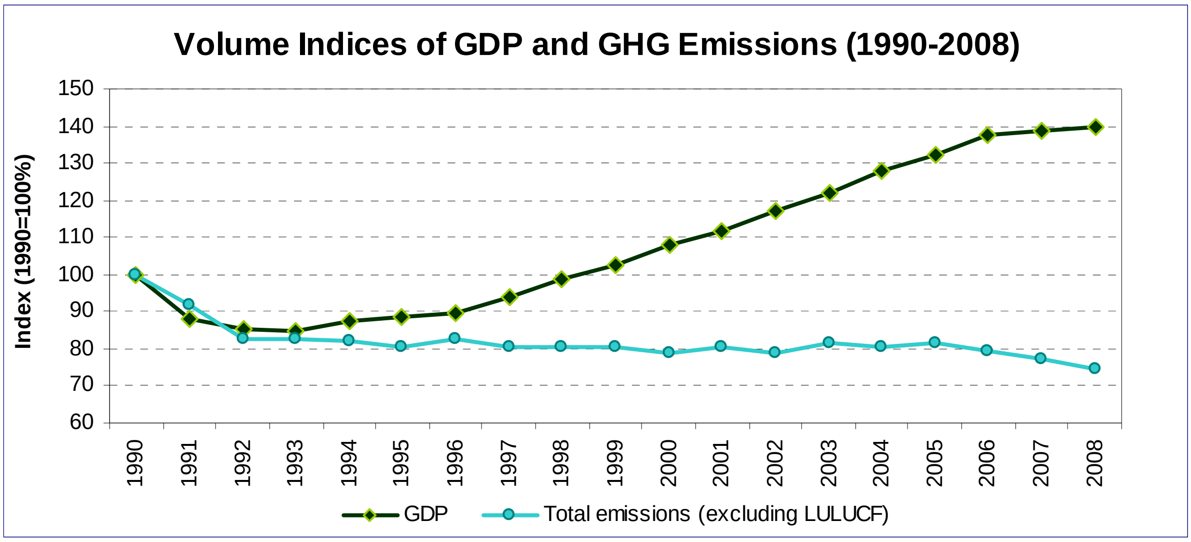


Figure 2.2. *Comparison of trends in GDP and GHG emissions*

In the third period, basically in the last 2-3 years, Hungary experienced an emission reduction of about 8% basically due to mild winters, higher energy prices, and modernization in the chemical industry.

Starting with the first period, the process of transition into market economy brought in its train radical and painful decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors (energy, industry and agriculture). Consequently, GHG emissions decreased substantially in these years by around 35 million tonnes CO_2 equivalent. Between the mid 80's and the mid 90's emissions fell back in the *energy* sector by around 25%, and even more, by around 50% in the *industrial processes* and *agriculture* sectors.
The most significant drop in energy use occurred in the industry especially in the energy-intensive industrial sectors (manufacture of basic metals and machinery, mining etc.). The industrial output of 1992 was two third of that of 1989. Several factories were closed down, capacity utilization was reduced, consequently the production decreased more or less drastically in each industrial sector. Some examples:

- Cement production: two plants were closed;
- Iron and steel production: two out of three plants were provisionally closed down;
- Aluminium: two out of three plants were closed down in 1991 (aluminium production stopped in 2006 eventually);
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed down (1988, 1991 and 1995).

The agricultural sector suffered a similar decline. As the result of the political and economic processes, 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%, the livestock by about 50%, and the use of fertilizers by more than 60%. As a consequence, the share of the agricultural sector in total GHG emissions decreased from 16.7% to 12.6%.

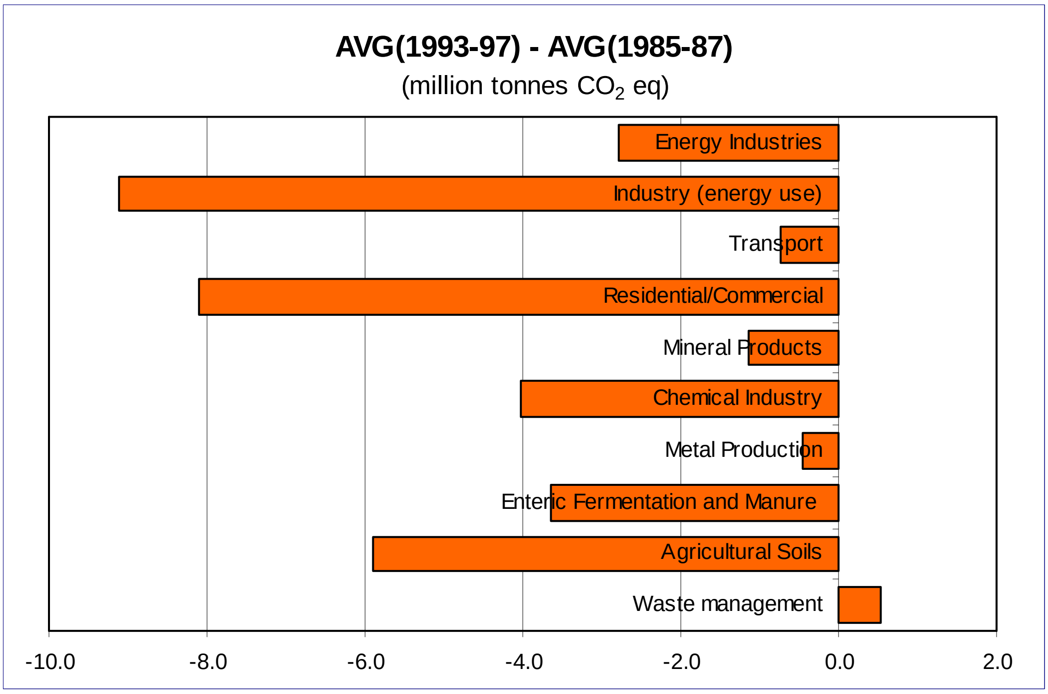


Figure 2.3. *Changes in emissions due to regime change (1985-95).*
AVG(1993-97) = average emissions of 1993-97

The small increase of emissions in the *Waste* sector is exceptional among all the sectors, and it 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.

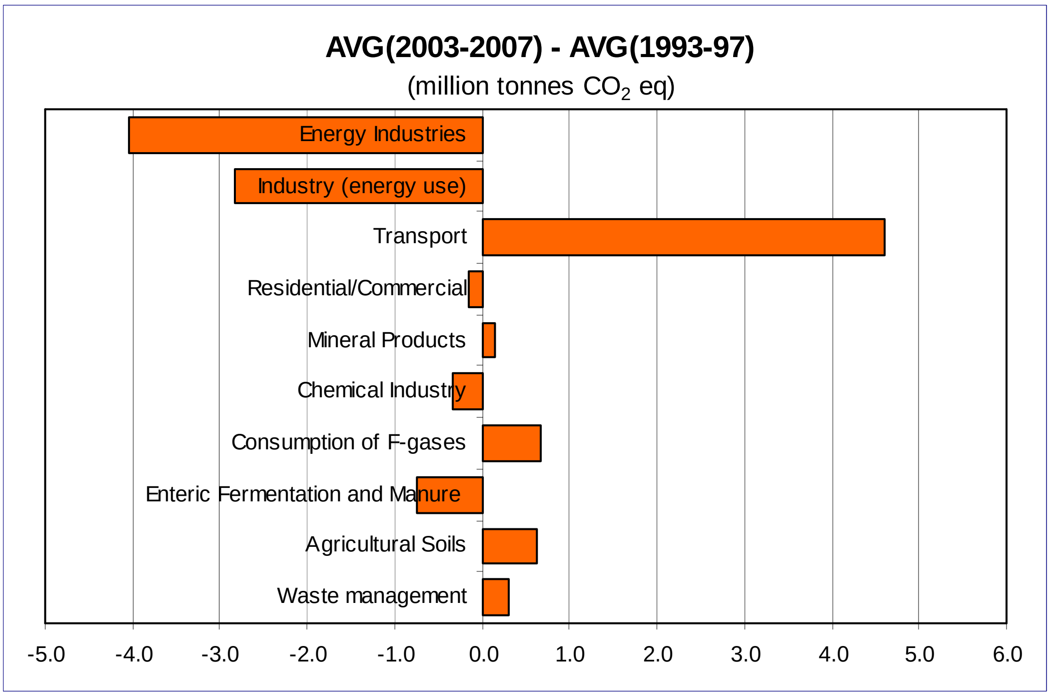


Figure 2.4. *Changes in emissions between 1995 and 2005*
AVG(2003-2007) = average emissions of 2003-2007

After the mid 90's, emissions seemed to have been stabilized around 79-80 million tonnes CO_2 equivalent. However, behind the quite stable emission level opposite processes could be observed which can be illustrated by the relatively bigger changes in the *energy sector*.

The fuel use of industry decreased further and had only a 15% share in CO_2 emissions. In contrast, emissions from transport increased significantly by more than 4 million tonnes CO_2 equivalent which represented a more than 60% growth.
In the third period, say after 2005, emissions fell by 6.8 million tones or 8.5%. The decreasing energy use by other sectors and manufacturing industries, and the diminishing process related emissions in the chemical industry were the main drivers of these changes. Most importantly, total fuel consumption in the residential sector decreased by almost 20% (including a 13% decrease in natural gas use) - mainly due to extreme mild winter in 2007 but probably the growing energy prices and the support for modernization of buildings might have played a role as well. Decreased production volumes and modernization in the chemical industry led to an emission reduction of 74%. In contrast, emissions from energy industries and transport grew further.

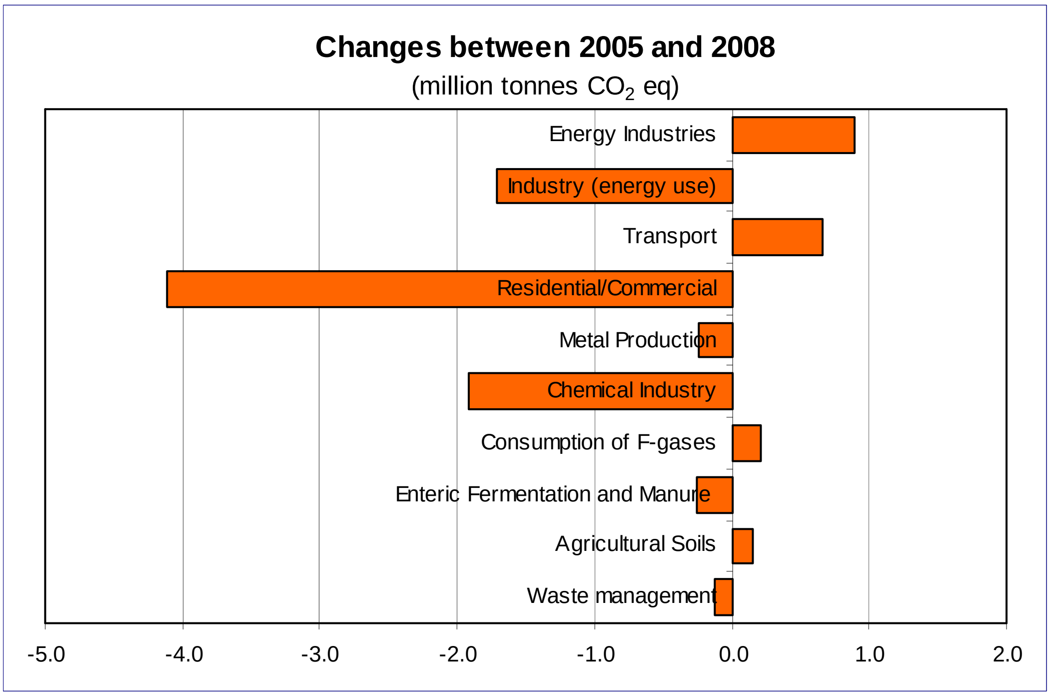


Figure 2.5. *Changes in emissions between 1995 and 2005*

Emissions (excluding LULUCF) decreased by 3.4% (-2.6 million tonnes) between 2007 and 2008. In comparison with 2007, emissions in 2008 were lower in all major sectors. The highest relative reduction (-20.6%) occurred in the industrial processes sector mainly due to lower production volumes and modernization in chemical industry (-62.6%). Out of the 2.5 million tonnes reduction, chemical industry was responsible for about 1.2-1.4 million tonnes. Further decrease of 0.9 million tonnes was mainly due to favourable changes in the fuel-mix used by the energy industries (less fossil fuel consumption).

2.2. Description and interpretation of emission trends by gas

The following table shows the emission data for each greenhouse gas (Gg CO_2 equivalent):

Table 2.2.2. *Trends in emissions of greenhouse gases in Hungary (1985-2008)*

GREENHOUSE GAS EMISSIONS (CO_2eq, Gg)	Base year	1990	1995	2000	2005	2006	2007	2008
CO_2, without LULUCF	85,024.99	72,559.68	61,436.27	58,543.15	60,970.82	59,655.71	57,882.50	56,224.66
CH_4, without LULUCF	11,892.23	11,172.40	9,237.88	9,373.77	8,801.48	8,715.31	8,554.27	8,376.84
N_2O, without LULUCF	19,260.59	14,925.44	8,643.54	9,455.46	9,765.57	9,546.71	9,070.52	8,127.98
HFCs	0.0	0.0	0.78	211.34	537.77	592.05	621.18	703.38
PFCs	268.49	270.83	166.82	211.26	209.39	1.53	2.38	2.41
SF_6	81.02	39.87	70.15	140.11	201.02	244.45	171.65	237.85
Total (excluding LULUCF)	**116,527.32**	**98,968.22**	**79,555.43**	**77,935.09**	**80,486.06**	**78,755.76**	**76,302.49**	**73,673.12**

Base year=average of 1985-87

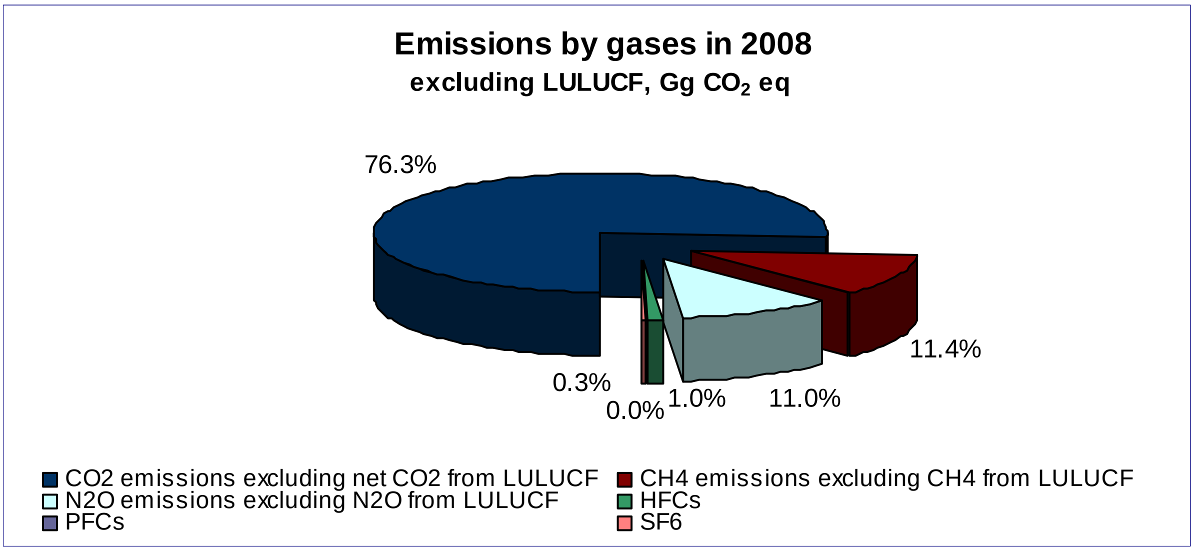


Figure 2.6. *Shares of emissions of greenhouse gases in 2008*

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 decline. From the second half of the 1990's emissions showed stagnating or slightly decreasing tendencies reflecting the effects of restructuring following the economic growth. The changes in the fuel-mix resulted in reduction of the specific emission levels.
As regards CH_4 emissions, two opposing effects should be considered. On the one hand, reductions in the livestock resulted in lower emissions. On the other hand, fugitive emissions increased as gas supply via pipelines became more and more widespread. Besides, emissions from waste disposal have grown, at least until 2005. This is the reason why the resultant trend is relatively stagnating or slowly decreasing.
Due to the above factors, also N_2O emissions significantly decreased in the beginning of the period, Later it showed a slightly rising trend, followed by another drop primarily reflecting the fluctuations in agricultural output and the modernization of nitric-acid production.

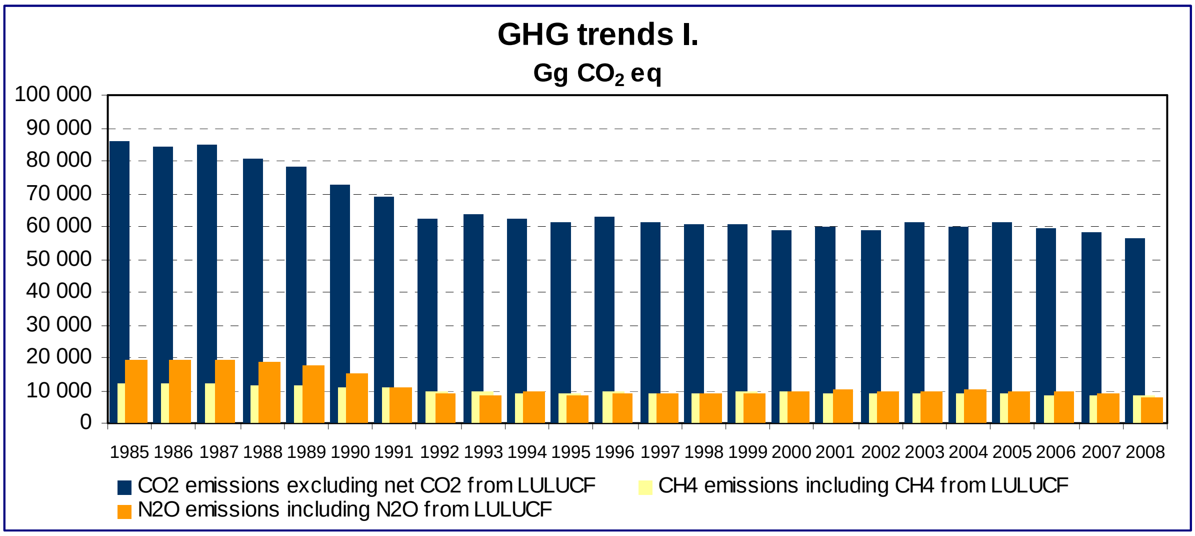


Figure 2.7. *Trend of emissions by gases*
Note: BY=average of 1985-87 but 1995 for F-gases

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 of emissions is obvious.

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 showed a slow but steady increase. Then the aluminium production ceased suddenly in 2006.

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

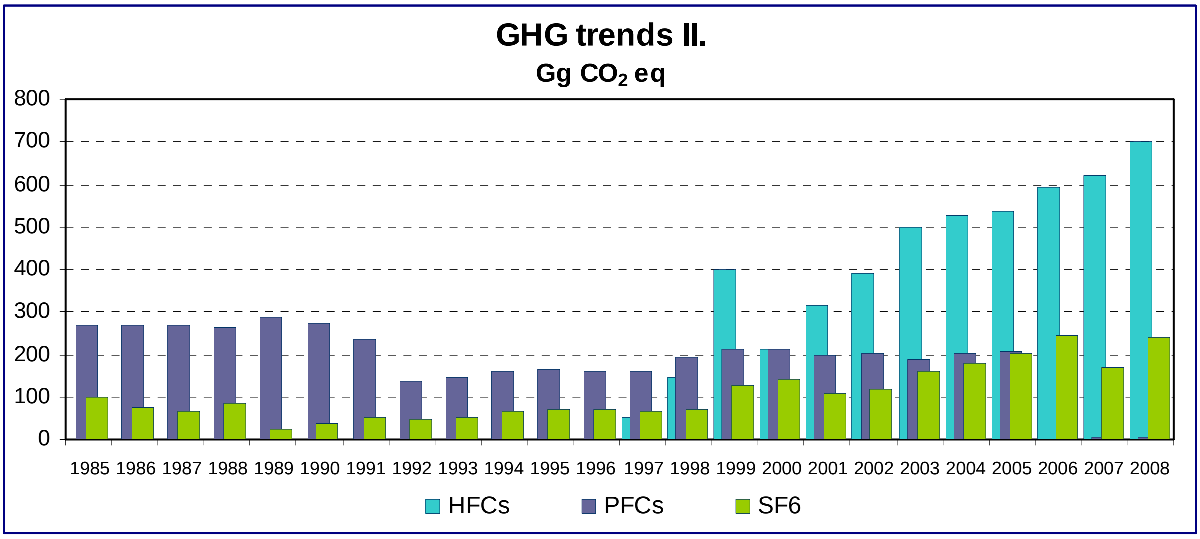


Figure 2.8. *F-gases trend (1985-2008)*
*Note: *BY=average of 1985-87 but 1995 for F-gases*

2.3. Description and interpretation of emission trends by category

The following figure 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. The biggest emitting sector was the energy sector contributing 75.0% to the total GHG emission in 2008. Agriculture was the second largest sector with 12.6% while emissions from industrial processes (with solvent and other product use) accounted for 7.3% and the waste sector contributed 5.1%. Compared to the base year, emissions were significantly reduced in the energy (-33.0%), agriculture (-52.0%), and industrial processes (-56.1%) sectors. In contrast, emissions in waste sector have increased since 1985 (+25.3%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.

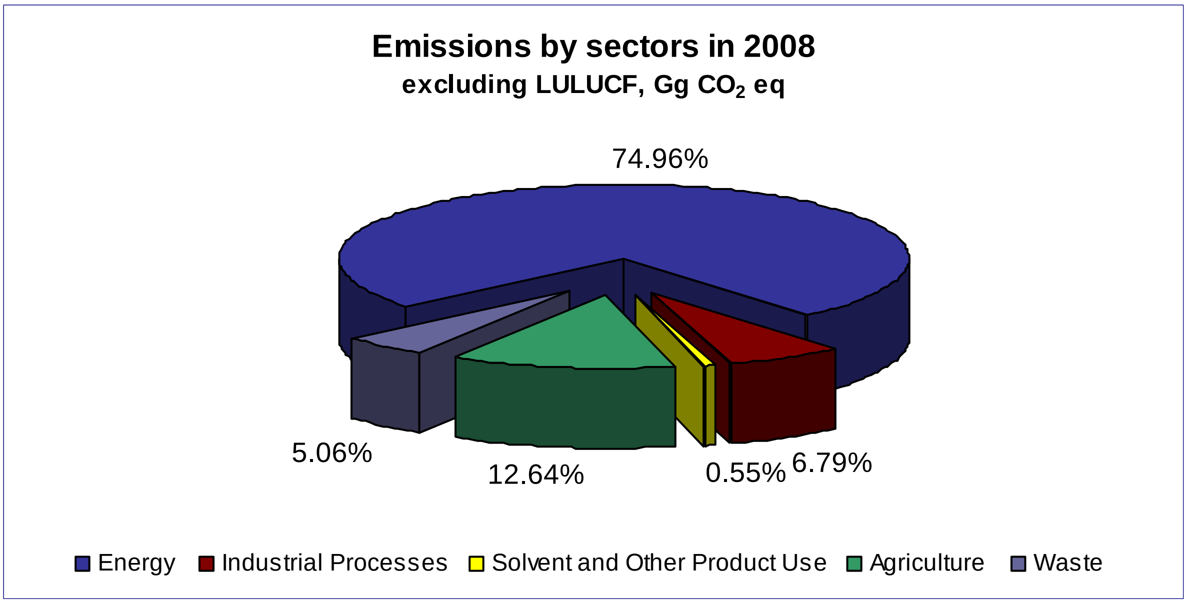


Figure 2.9. *Shares of sectors in 2008*

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 favorable composition. In the last three years, growing emissions from energy industries and transport could be observed which were more than offset by drastic reduction of emissions by the residential sector and manufacturing industries.

The e*nergy sector* was responsible for 75.0% of total GHG emissions in 2008. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.3% to sectoral emission. Considering fuel use, gases had the highest proportion (51.8%), liquids and solids represented 26.3% and 14.9%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 6.2%. The most important subsector was energy industries with a proportion of 35.6%, followed by other sectors (25.0%) and transport (23.3%). Fugitive emissions from fuels played only a small role with 3.9%. The most dynamically increasing category was transport which had 65.7% higher total emission in 2008 compared to the base year.

The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation which caused sudden decrease in energy demand. Besides, ongoing changes in the fuel-structure, i.e. solid fuel as the most important source in the 80's had been replaced by natural gas, led to further decrease of total emission.

Overall emissions from the energy sector decreased by 2.0% between 2007 and 2008. Although slightly more electricity was generated in domestic power stations, the lower share

of fossil fuels and the higher share of nuclear and renewable energy for electricity and heat production resulted in 4.3% decrease in emissions from energy industries. The growth in GHG emissions from transport was quite moderate (0.4%) after a more than 80% increase between 1995 and 2007. The almost six-fold rise in biofuel use could nearly meet the increased energy demand of transport in 2008. The tertiary sector used some 8% less energy, and the residentials' energy consumption remained below expectations. Taking into account the growing energy prices (e.g. the price of pipelined gas increased by 70% in the last two years), energy-saving measures must have contributed to the trend of emissions.

In 2008, a*griculture* was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH_4 and N_2O gases: 83.0 percent of total N_2O emissions were generated in agriculture in 2008. Emissions from agriculture decreased by 52.0% over the period of 1985-2008. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by about 35 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 16.7% to its present share of 12.6%.

Between 1996 and 2008, agricultural emissions showed a slightly decreasing trend with fluctuations up to ±6%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers increased by about 60% which caused growing nitrous-oxide emissions from agricultural soils.

Agricultural emissions fell by 2.0 between 2007 and 2008. This reduction was mainly driven by the 9.3% decrease in swine population due to high forage prices in 2008. Besides, rising fertilizer prices led to 8% lower fertilizer use and thus lower N_2O emissions from agricultural soils which could not be offset by increased emissions from crop residues.

The *industrial processes* sector was the third largest contributing 6.8% to total GHG emissions in 2008. (Solvent and other product use added further 0.6% to total emissions.) The most important greenhouse gas was CO_2, contributing 80.7% to total sectoral GHG emissions, followed by F-gases with 18.9%. Within this sector, 45.4% of the emissions came from mineral products, followed by 18.9% from consumption of halocarbons and SF_6 and 13.2% from chemical industry. Process related industrial emissions decreased by 56.1% between base year and 2008, and by 31.8% between 2005 and 2008.

The key driver of the 20.6% reduction between 2007 and 2008 was the chemical industry. Ammonia and nitric acid production decreased by 26%, which was reflected also in the lower energy use of chemical industry, and on top of this, the new nitric acid plant, thanks to a JI project, almost abolished the factory's nitrous oxide emission in the magnitude of one million tonnes CO_2 equivalent. Besides, brick production decreased, and the cement industry was able to lower its emissions by using more additives to lower the fraction of clinker in the cement. Although emissions of F-gases represent only 1.3% of the total GHG emissions, their trend requires special attention. As these gases are harmless for the ozone layer, the use of HFCs in the refrigeration and air conditioning industry got widespread thus their emission increased tenfold.

The *waste sector* represented 5.1% of total national GHG emissions in 2008. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+25.3%). However, the growth of emissions seemed to be stopping in recent years, moreover a reduction of 3.4% could be observed between 2005 and 2008. In all the years, the largest category was solid waste disposal on land, representing 78.7% in 2008, followed by wastewater handling (19.5%) and waste incineration (1.8%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade.

The *LULUCF sector* was a net sink of carbon because of the huge amount of carbon uptake of forests, due to the continuous afforestation efforts and the sustainable forest management. In the inventory period, the forest area increased by 350,000 hectares, and the amount of the current annual increment exceeded the annual harvest in all years. The complex dynamics of the land use and land-use changes lead to highly fluctuating estimates of sectoral removals.

Our estimates indicate an average annual 3.5 million tonnes removal with fluctuations in the range of ± 96 percent in the inventory period.
In 2008 the LULUCF sector accounted for 4.6 million tonnes carbon-dioxide removals. The removals of forests amounted to 4.9 million tonnes, while the living biomass of orchards and vineyards are a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. In 2008 the emission of the living biomass of vineyards and orchards accounted for net 0.17 million tonnes CO_2.

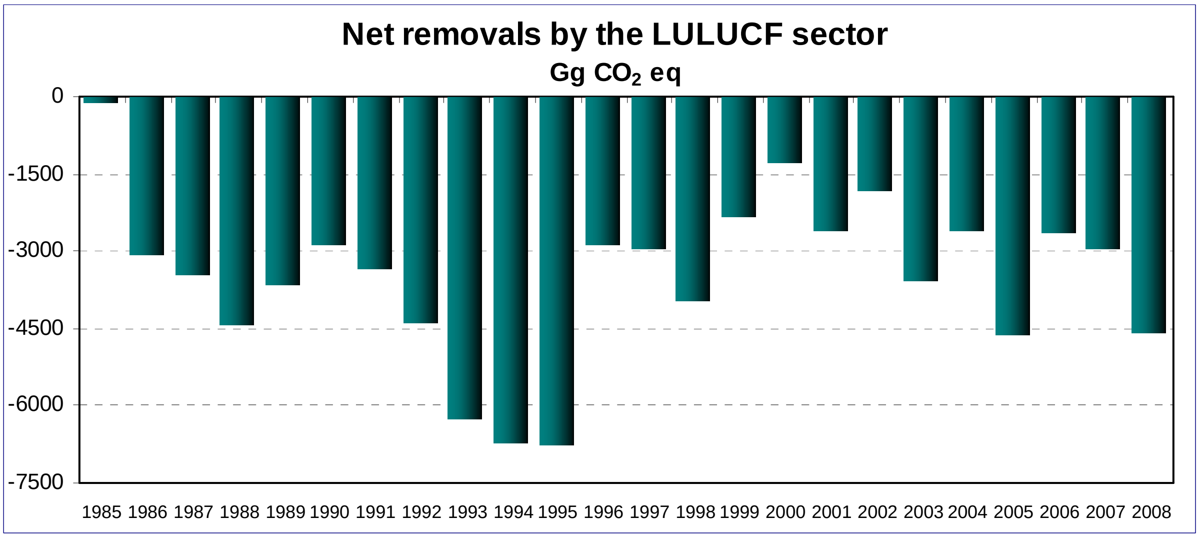


Figure 2.10. *Sinks of LULUCF*

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):

Table 2.2.3. *Trends in emissions of indirect greenhouse gases and SO_2. The database is not complete for the beginning of the period.*

Indirect gases	1985	1986	1987	1988	1990	1991	1992	1993	1994	1995	1996
NO_X, Gg	262.5	264.2	264.9	257.8	238	203.1	183.3	184	187.4	190.07	195.81
CO, Gg	931.1	--	--	963.1	997	913.4	835.8	796.1	774.29	761.29	726.87
NMVOC, Gg	232	263	228	215	205	149.6	141.8	149	142.4	150.3	150.1
SO_2, Gg	1403.6	1361.8	1285.3	1218	1010	913	827.3	757.3	741	704.96	673.23
	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008
NO_X, Gg	199.5	202.62	185.08	183.21	182.94	210.70	185.26	203.15	202.44	185.43	170.58
CO, Gg	733.36	736.93	592.66	578.54	573.55	599.82	583.37	588.20	594.31	576.70	570.34
NMVOC, Gg	145.4	140.6	166.01	162.25	160.15	169.01	157.04	176.23	186.71	167.68	169.65
SO_2, Gg	658.51	591.79	488.96	403.89	364.90	347.83	248.78	146.65	123.11	98.59	106.73

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)

3.1. Overview of sector

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2, T3
Emission factors: D, CS, CR, PS

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources. *Figure 3.1* shows the emission trends in the sector by gases. Underlying activity data, namely total fuel consumption of the sector, appear on the graph below, too.

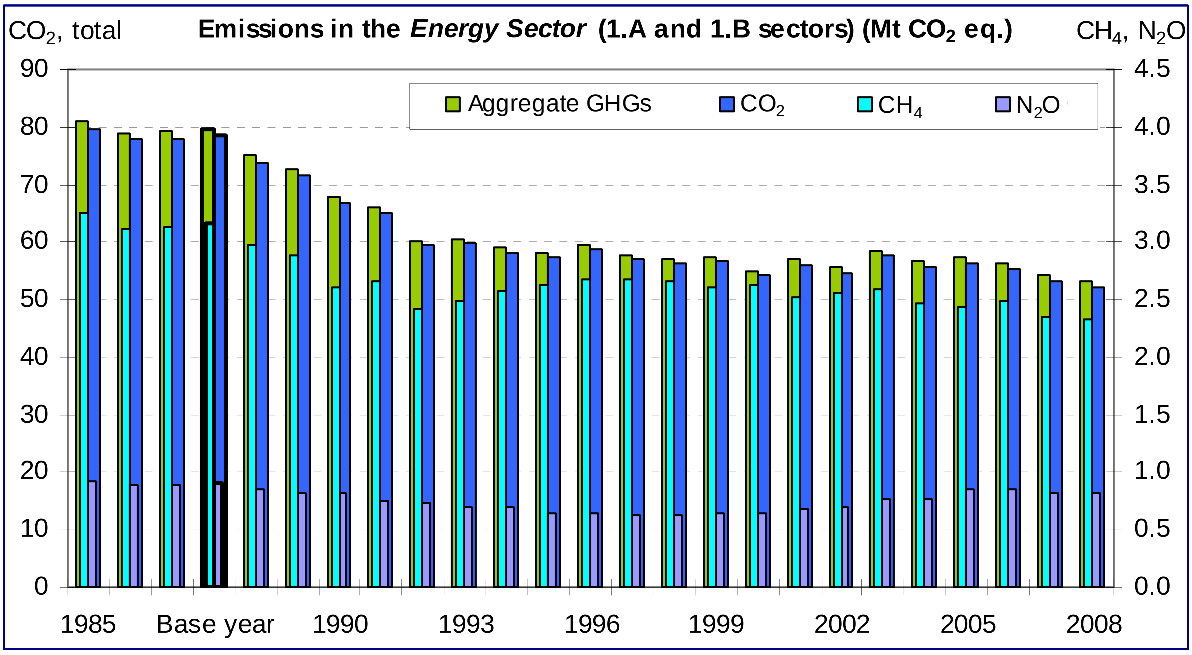


Figure 3.1. *CO_2, CH_4 and N_2O emissions in the Energy Sector (1985-2008)*

The principal driver of emissions in this sector is fuel consumption. *Figure 3.2* represents the distribution of combusted fuel types in the base year and 2008.

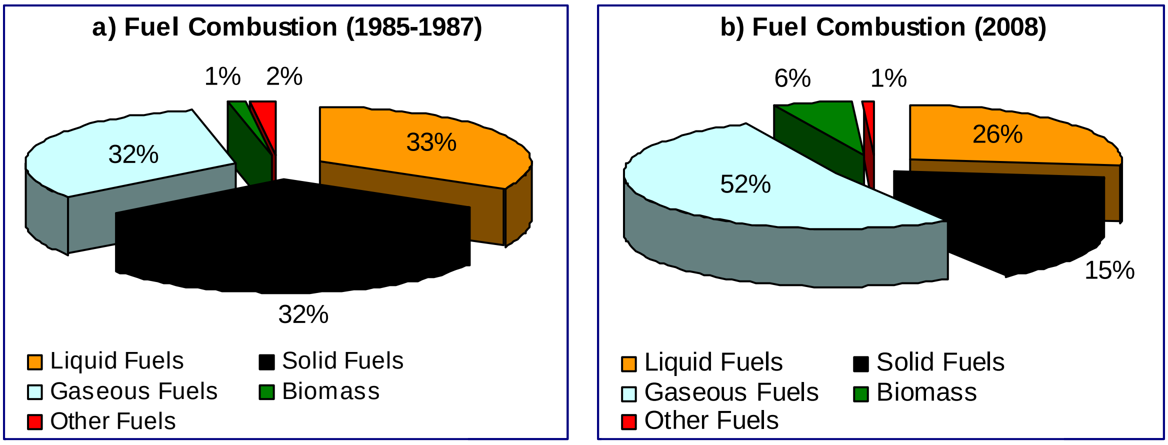


Figure 3.2. *Fuel combustion in the base year (a) and 2008 (b)*

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.3% to sectoral emission, followed by CH_4 with 4.2% and by N_2O with 1.5%. Among fuels, gases have the highest proportion (45%), liquids and solid have less (30% and 23%) and other fuels (waste) have the lowest representing 1% of the sectoral GHG emissions. Besides the sudden decrease in energy demand in the years of economic transformation, also the changes in the fuel-structure in the '90s when the most important source in the base years namely solid fuel has been replaced by natural gas, led to decreased total emission.

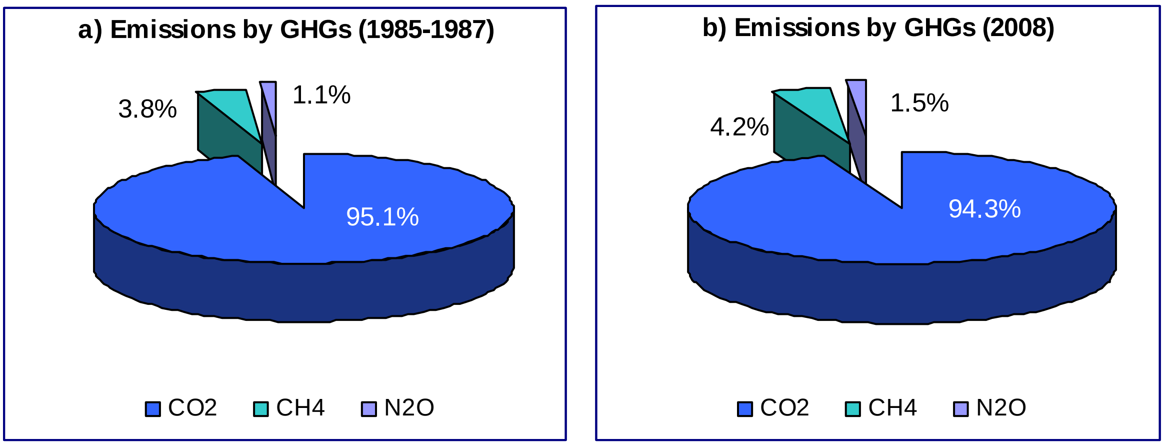


Figure 3.3. *Distribution of emission of GHGs in the Energy Sector in the base year (a) and 2008 (b)*

As regards methane emission, this sector represents 3.4% (with LULUCF) of the total greenhouse gas emission. Primarily, this results 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 27.8%, which represents the third highest emission compared to other sectors *(Figure 3.4.)*.

As regards nitrous oxide emission, this sector represents 1.2% (with LULUCF) of the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 10.2%, which represents the third highest emission compared to other sectors *(Figure 3.4)*.

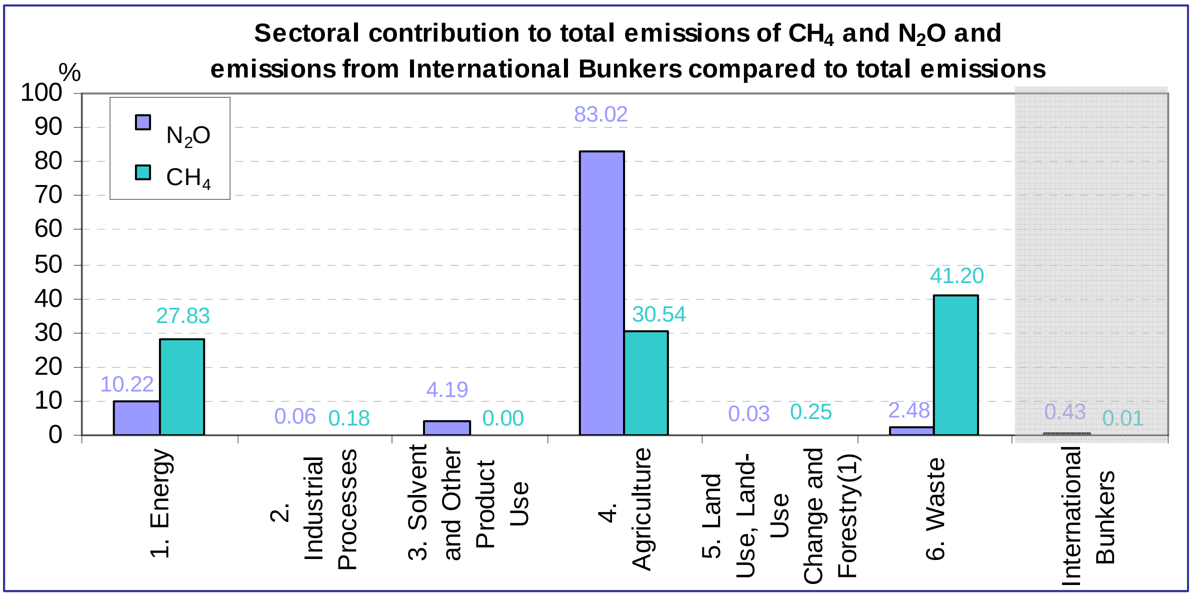


Figure 3.4. *Sectoral contribution to total emission of CH_4 and N_2O in 2008*

The emissions of the sector strongly depend on the amount of combusted fuel. *Figure 3.5*/a) illustrates the share of energy consumption among subsectors in this sector, while *Figure 3.5*/b) shows the subsectoral distribution of the total GHG emissions in the *Energy Sector*. The most important subsector of the *Energy Sector* is the *Energy Industries* (1.AA.1) with a proportion of 36%, followed by *Other Sectors* (1.AA.4) and *Transport* (1.AA.3) representing 25 and 23% of the total emissions in this sector, respectively. Similarly to the previous year the least contribution to the emission from fuel combustion has *Manufacturing Industries and Construction Sector* (1.AA.2) with 12%. *Fugitive Emissions from Fuels* (1.B) play only a small role in emissions of the sector with 4%.

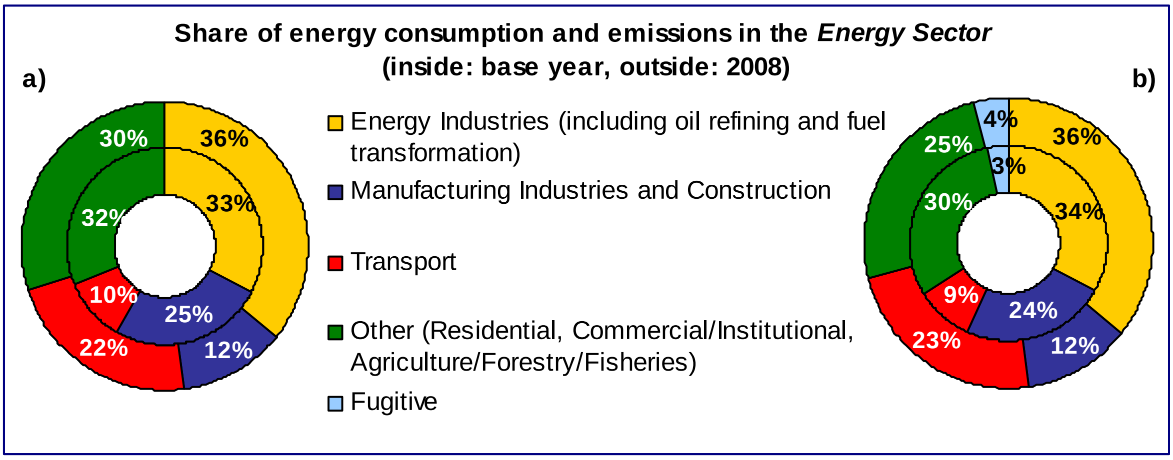


Figure 3.5. *Proportions of energy consumption and emissions in the Energy Sector in the base year and 2008*

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 consumption for each subsector prepared by Energy Centre – Energy Efficiency, Environment and Energy Information Agency Non-Profit Company owned by the Ministry of Transport, Telecommunication and Energy. The energy statistics has a chapter about the energy carries balances by branches. Nowadays, division into branches follows mainly the structure of ISIC 3.1 (see *Annex 2*).

Detailed EU-conform statistics from industrial and energy industrial activity help to compile the *sectoral approach*. Before 1998 some IPCC categories could be found only in aggregation with similar branches in the statistics, therefore the Hungarian inventory still follows this tradition in case of manufacturing metal products (IPCC 1.AA.2.A and 1.AA.2.B are included under 1.AA.2.A) to keep consistent time-series. Non-energy use of fuels and fuel used for transportation are included in the consumption of branches, therefore tables of fuels related with the mentioned activities cannot be adopted completely in their original form. Tables from the different transportation forms and non-energy use of fuels as well as personal communication with the statistics' provider allow filling in the CRF tables according to the guidelines.

Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary (HCSO, 2009) and Energy Statistics, discussions with the Hungarian Oil and Gas Company Plc. (MOL). We would like to refine methods, input data and uncertainty, hopefully the government decree (see Ch. 1.3) allows us to establish a database with help of the Mining and Geological Bureau of Hungary.
LPG and petroleum coke was taken into account as liquid fuels having significant influence on the IEF value of this fuel type.

3.2. Fuel combustion (CRF sector 1.A)

3.2.1. Comparison of the sectoral approach with the reference approach

The quantity of CO_2 from energy consumption was determined on national level (*Reference Approach*) and on sectoral level (*Sectoral Approach*) as well.
The UNFCCC reference approach was compared with the sectoral approach as a check of combustion-related emissions. The check was performed for all years from 1985 to 2008 and is an integral part of reporting to the UNFCCC. The analysis includes also the comparison from the base year (1985-87).
The reference approach, in theory, includes all CO_2 emissions from all fossil fuel uses in a country and should be compared with a set of emissions from the sectoral approach that includes all CO_2 emissions from energy and non-energy (including feedstock) use of fossil fuels. In the CRF reporting software, the reference approach is directly compared with the sectoral fuel combustion total.
This direct comparison of the energy outputs from the reference approach and the sectoral approach used in the Common Reporting Format (CRF) shows a reference approach total that is consistently larger than the sectoral approach total (*Figure 3.6*).

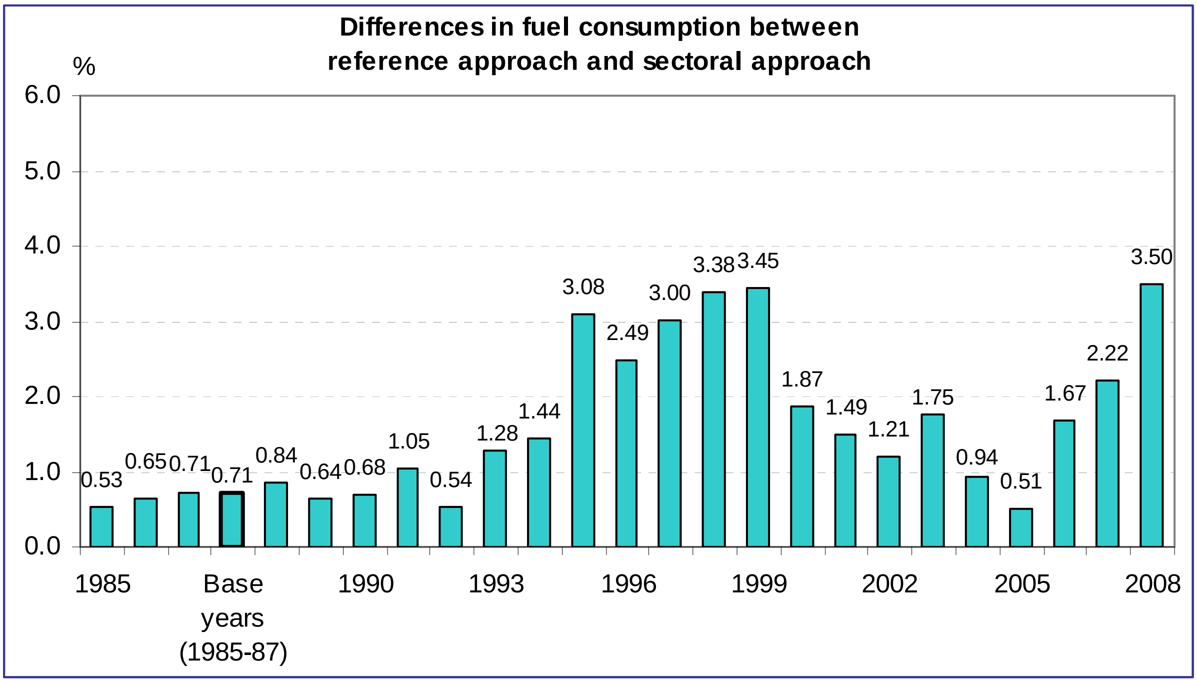


Figure 3.6. *Comparison of sectoral and reference approach – fuel consumption*

In 2008, comparing the two approaches the difference was 3.5% in energy consumption (*Figure 3.6*) and 5.96% as regards CO_2 emission (*Figure 3.7*). The differences in each fuel types were analyzed thoroughly and the following tables summarize the results of this verification.

Differences in *liquid fuel* consumption:

Fuel consumption in PJ	**Reference approach**	**Sectoral approach**
Liquid fuels	298.477	215.905
2.G feedstock and non-energy use of fuels (Industrial processes)	-55.695	0
Bitumen used as asphalt and road paving (Industrial processes)	-9.317	0
Petroleum coke used as feedstock in industrial processes (2.A.7)	-0.316	0
Liquid fuels used as feedstock in solid fuel transformation	-0.313	0
Other non-energy use of other oils (not included in CRF)	0	1.752
Transformation losses (not included in CRF)	0	8.351
Blending of refinery products (not included in CRF)	0	6.865
Total	**232.836**	**232.873**

Differences in *gaseous fuel* (natural gas), fuel consumption and CO_2 emission:

Fuel consumption in PJ	**Reference approach**	**Sectoral approach**
Fuel consumption – energy sector	442.161	425.273
Fuel consumption – feedstock	-14.719	0
Network losses – fugitive emission	0	2.169
Total	**427.442**	**427.442**
CO2 emission in Gg	**Reference approach**	**Sectoral approach**
Fuel consumption – energy sector	24,410.088	23,738.541
Fuel consumption – feedstock	-550.477	0
Network losses– fugitive emission	0	121.073
Total	**23,859.611**	**23,859.614**

Differences in *solid fuel*, fuel consumption:

Fuel consumption in PJ	**Reference approach**	**Sectoral approach**
Solid fuels	130.290	114.203
Derived gases	0	8.097
Feedstock in industrial processes	-0.131	0
Other coal product used as feedstock (not included in CRF)	0	2.754
Liquid fuels used as feedstock in solid fuel transformation	0	-0.313
Transformation and network losses (not included in CRF)	0	5.418
Total	**130.159**	**130.159**

Other fuels (waste), fuel consumption and CO_2 emission:

Fuel consumption in PJ	**Reference approach**	**Sectoral approach**
Fuel consumption – energy sector	7,0734	7,0734
CO2 emission in Gg	**Reference approach**	**Sectoral approach**
Fuel consumption – energy sector	394,048	394,048

In spite of the fact that the difference between top-down and bottom-up approaches are relatively high, more than 2 percent for both parameters, these comparisons tell that the sectoral approach covers the total amount of combusted fossil fuels in Hungary.

The range of differences are between 0.51% (2005) and 3.5% (2008) with a 1.59% mean value as regards the fuel consumptions, and 2.13 % (1995) and 5.96 (2008) with a 3.44% mean value as regards the CO_2 emissions.

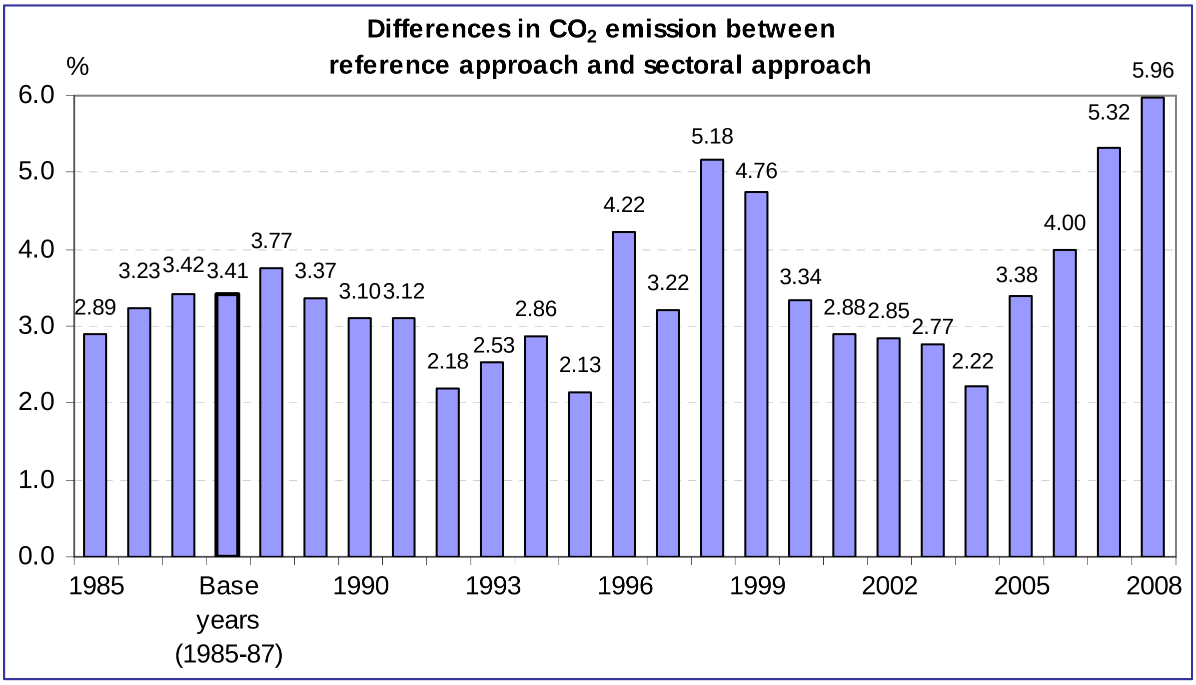


Figure 3.7. *Comparison of sectoral and reference approach – CO_2 emission*

3.2.2. International bunker fuels

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. 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 default EF was used throughout the entire time series. Naturally, changes in kerosene consumption reflect the travelling/transport needs. This is clearly illustrated in *Table 3.1*, which shows the air travelling/transport performance of the past years.

Air transport	2000	2003	2004	2005	2006	2007	2008
Passengers carried (thousands)	2,476	2,719	**3,193**	**3,785**	**4,551**	**4,896**	4,340
Transported quantity of goods (kt)	22	13	19	16	16	17	14
Quantity of kerosene (TJ)	8,957	8,358	8,610	9,368	9,210	10,145	11,303

Table 3.1. *Air travelling and transport performance in Hungary since 2000 in selected years (Source: HCSO, 2009; Energy Centre, 2009)*
Data in green and bold are revised by HCSO

Emissions from in-country aviation, which represent a very low proportion, were taken equal to the emissions from consumption of aviation gasoline, and calculated in those years when the related data were available in the energy balance. Where aviation gasoline was not indicated in a separate line, consumption and emissions are calculated 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 be 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: webpage of Központi Közlekedési Felügyelet)

3.2.3. Feedstocks and non-energy use of fuels

For the first time feedstocks and non-energy use of liquid fuels were removed from the sectoral approach for the entire time-series, the CO_2 emission originated from non-combustion can be found in the *Industrial Processes Sector*. Feedstocks in chemical industry and non-energy uses have been considered in connection with sectors presented in *Table 3.2.*

The amount of fuels used is normally the same or nearly the same as the values published by IEA, because Energy Centre 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 oils*. It should be emphasized that these poolings have no significant effects on the emission calculations.

Fuel type	Allocated under the sector ...	IPCC code
Natural gas	Industrial processes – Ammonia and carbon black production	2.
Naphtha	Industrial processes –	2.G
Bitumen	Industrial processes –	2.A.5-6
Gas/Diesel Oil	Industrial processes –	2.G
LPG	Industrial processes –	2.G
Other oils	Industrial processes –	2.G
Coal (lignite)	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7
Petroleum coke	Industrial Process – Mineral Products – Bricks and ceramics	2.A.7

Table 3.2. *Allocation of feedstocks and non-energy use of fuels*

Two new categories were added to feedstocks in 2008 submission, since emissions of these fuels are calculated in the *Industrial Processes Sector* using the EU ETS database of manufacturing bricks and ceramics. Coal and petroleum coke serve as additives increasing the porosity of bricks.

3.2.4. CO_2 capture from flue gases and subsequent CO_2 storage

3.2.5. Country-specific issues

3.2.6. Energy Industry (CRF sector 1.AA.1.)

3.2.6.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2, T3
Emission factors: D, CS, CR, PS
Key source: Level and Trend: Public electricity and heat production, CO_2; Petroleum refining, CO_2

This subsector includes facilities generating electricity, district heating stations, oil refineries and coking and briquetting plants. On an overall level, there are the largest energy consumers. In 2008, 36% of the domestic energy consumption, of which 92% was fossil fuel, was used by energy industries (see *Figure 3.5*).

Emissions in the *Energy Industries Sector*

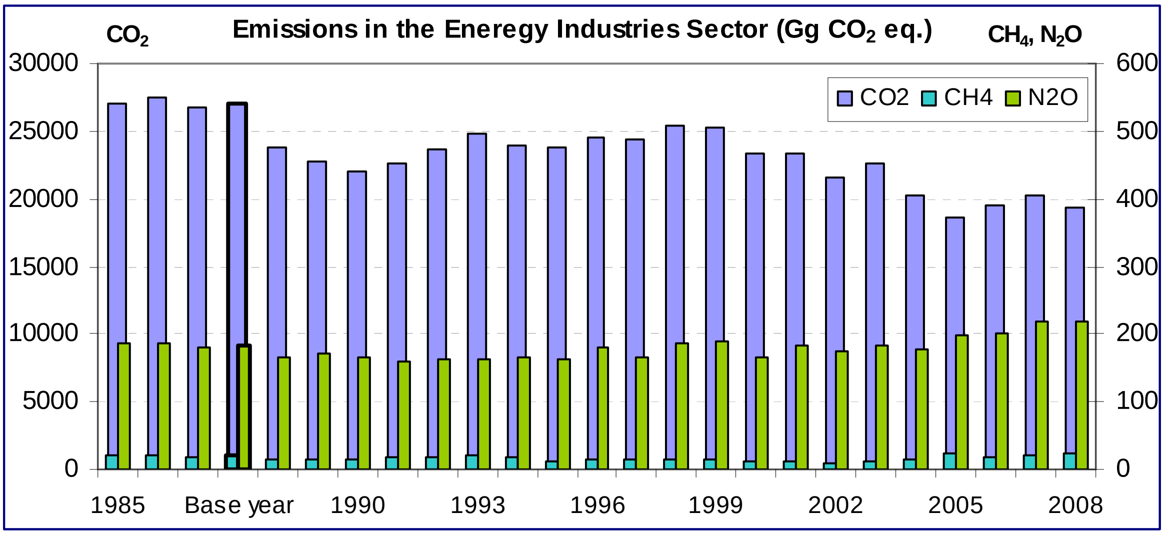


Figure 3.8. *Trends of CO_2, CH_4 and N_2O emissions in the Energy Industries (1985-2008)*

3.2.6.2. Methodological issues

Activity data

Energy consumption data were taken from the energy balance (1985-2008) of the Energy Statistics Yearbooks prepared by Energy Centre.
The Hungarian coal terminology slightly differs from that of the 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 anthracite, hard coal, brown coal and lignite in the fuel balance, while the sectoral energy consumption for coal is the aggregate of hard coal, brown coal, lignite, gas coal and coking coal. In the latter case it is necessary to use additional information, from e.g. statistical yearbooks (HCSO, 1985-2008) or annual coal questionnaires (1990-2008) prepared for IEA by Energy Centre, 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 the Energy Statistics Yearbooks, the quantities of fuels are expressed in 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 3.9. shows the changes in fuel consumption in the *Energy Industries Sector*.

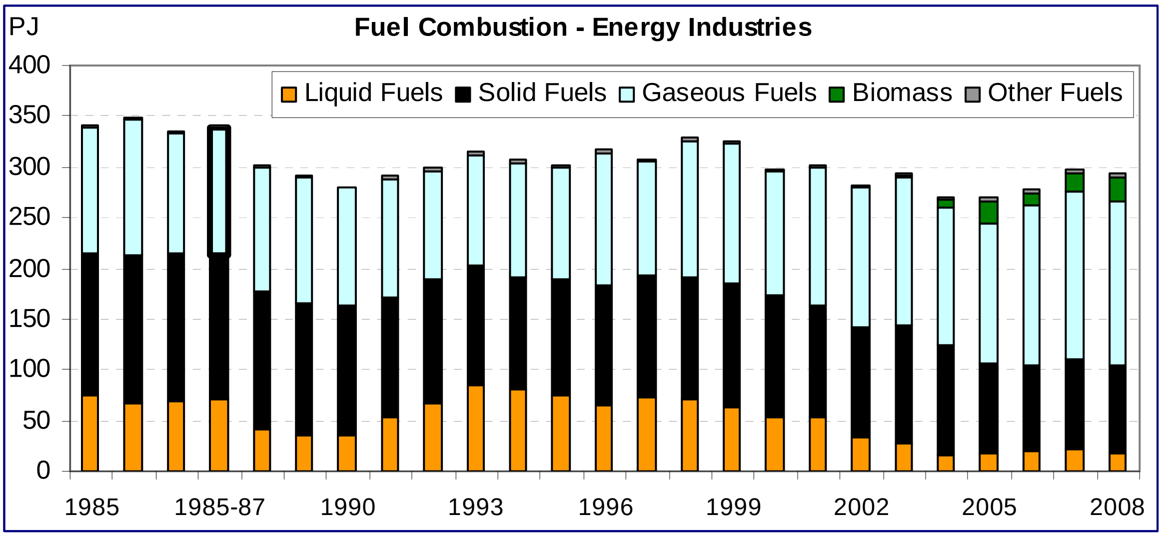


Figure 3.9. *Fuel combustion in the Energy Industries Sector (1985-2008)*

The total fuel consumption shows a slight decrease till 2005 after the second peak in 1998, along with a strong fluctuation. Within this, the consumption of liquid and solid fuels has decreased significantly. In contrast, the consumption of natural gas has increased to a slight extent. Since 2005 the total energy consumption of the sector has been increasing, but fossil fuel consumption has not increased in parallel. 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 in 2005. In 2006 the greatest power plant of Hungary reduced biomass-use, because the amount of obligatory purchased electricity was less than in 2005, this is illustrated on *Figure 3.9*. In 2007 the produced electricity increased by more than 11%, in parallel the fuel consumption (mainly natural gas) increased only by 9%, because the efficiency of natural gas combustion is better than that of the others. Biomass burning in power plants became again popular on favorable terms, which was induced by the EU carbon trading. In 2008, the produced electricity from fossil fuels and also the fossil fuel consumption of this sector decreased again, but the total generated electricity – including nuclear, waste and renewable sources – was a bit higher than in the previous year (MVM, 2009). The fuel consumption of oil refining has been quite uniform with a very moderate decreasing since 2005, but its behaviour does not affect the whole tendency of the sector, because the contribution of its fuel consumption and GHG emissions is less than 10%.

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	***95.76***	***0.98***
Lignite (brown coal + lignite)	***107.86***	***0.977***
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Coke Oven Gas	***43.5***	***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	***74.06***	***0.99***
Residual Fuel Oil	***81.96***	***0.99***
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	98.08	0.99
Other Oil	***80.50***	***0.99***
Natural Gas	56.1	0.995
Biomass (Solid and Gaseous)	109.63	0.99
Waste	***55.71****	***1.00***

Table 3.4. *CO_2 emission factors used in energy industry in the 2008 inventory year (Source: Revised 1996 Guidelines (IPCC, 1997); in bold and italics – EU ETS database of Hungary see Annex 2.4)*

**For waste only IEF is reported in summary the table, because the emission was calculated from country-specific waste amount and component data taken from Waste Information System database and the emission factors were calculated using the default or measured (from EU ETS) carbon content and fossil carbon fraction data from Table 2.4 – 2.6 in the 2006 Guidelines.*

Detailed description of country and plant specific CO_2 emission factors can be found in *Annex 2.4*. Default emission factors for methane and nitrous oxide have been used in the case of liquid fuels since last 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		Petroleum refining	
Fuel type	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Coal	1.25 [3)]	1.50 [2)]	1.50 [3)]	80.00 [3)]	–	–
Natural Gas	0.50 [3)]	3.00 [3)]	2.40 [3)]	5.00 [3)]	1.00 [2)]	0.10 [2)]
Residual Fuel oil	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]
Gas/Diesel Oil	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]	3.00 [2)]	0.60 [2)]
LPG	–	–	–	–	1.00 [2)]	1.00 [2)]
Firewood	30.00 [1)]	4.00 [1)]	–	–	–	–

Table 3.5. *Special emission factors for methane and nitrous oxide in energy industry*
Source: 1) Revised 1996 Guidelines (IPCC, 1997) and 2006 IPCC Guidelines
2) 2006 IPCC Guidelines
3) expert judgement based on technology and range of the EF values of international publications (Tajthy, 1994)

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

3.2.6.3. 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 are not consistent. Energy consumption of the *manufacturing of solid fuels* is calculated only for the last three years (2006-2008). Until 2005 it is part of the C*hemicals* and *Other Industry* categories. The statistics of gas coke distillation was revised in 2003, but the fuel consumption of this activity cannot be reconstructed from the actual national statistics.

3.2.6.4. Source-specific QA/QC and verification

As mentioned above, energy consumption data were subject of several rounds of verification before use (more details in *Annex 2*).
Energy statistics with those provided to international organizations (prepared also by Energy Centre) are and will be compared after their submission to IEA. This verification pointed out a reallocation problem for 2007 and was corrected in this submission. More details are in the *section 3.2.9.5*.
Verified energy use from EU-ETS was compared to statistical data (more details in *Annex A2.3*). It was noticed that data in metric tonnes are similar in the ETS to those in the statistics, but there are some differences in energy values due to different NCVs. Since the energy consumption in *sectoral approach* should be compared with those of *reference approach*, we kept the NCVs of energy statistics, however emission factors of coals were corrected to achieve consistency in energy balance and verified emissions, too. Measured oxidation factor was also applied in the calculation for the above mentioned reason.
As the main fuel consumption is related to public electricity and heat production, a

comparison was also performed with independent dataset collected by the Hungarian Energy Office. Only minor differences were discovered, the main discrepancies related to liquid fuel types.

3.2.6.5. Source-specific recalculations

As recommended by the ERT and required by the guidelines, emissions from waste incineration for energy purposes has been re-allocated from the waste sector to the energy sector. However, emissions estimation in the energy sector is somewhat different from the methodology used in the waste incineration category. Activity data in this source category are expressed in energy consumption units (TJ) whereas in the waste sector mass of waste serves as basis of calculations. For our calculations three main activity data sources were used: data from the Waste Incineration Works (FKF) of Budapest (1985-2008), the Hungarian Waste Management Information System (2004-2008) and the ETS data (2006-2008). The Hungarian Waste Management Information System comprises facility level data on mass and composition of waste in line with the European Waste Catalogue (EWC codes) but also on waste management methods in accordance with the Waste Framework Directive. The latter made it possible to distinguish between waste incineration on land (D10) and use of waste principally as a fuel or other means to generate energy (R1).
To convert mass of waste to energy, the following conversion factors were used:

EWC codes/type of waste	GJ/t	Range	Source
02: Wastes from agriculture and food proc.	**16**	12.2-19.5	ETS data
03: Wastes from wood processing	**14**	13.2-14.7	ETS data
Rubber (tires)	**26**		ETS data
Plastic	**27.5**	22.8-32.1	ETS data
MSW	**8.5**		FKF (2007)
Paper	**17**	15.7-18.6	Literature
Hazardous waste	**12**		ETS data
Wastes from waste management facilities	**20**		Estimation
Tire textiles	**28.7**	27.4-30	ETS data

Table 3.6. *NCVs for different waste types in 2008*

As only CO_2 emissions resulting from incineration of carbon in waste of fossil origin should be included in the national CO_2 emission estimate, the fossil fraction of waste had to be determined. To do so, the recommendations of the Background Paper (page 459) published as a complement to the Revised Guidelines were followed, 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. On the other hand, the incineration plant also calculated the ratio of the fossil part for 2003, which was 52%, i.e. higher than the default value.
For the more recent years of 2004 to 2008, data of the detailed Waste Management Information System were used which made possible to apply Tier 2 method for calculating CO_2 emissions. For the calculations, country-specific waste amount and composition data were taken from this database and the emission factors were calculated using the default carbon content and fossil carbon fraction data from Table 2.4 – 2.6 in the 2006 Guidelines. In case of the two biggest incinerators, plant specific data were used. The Waste Incineration Works (FKF) of Budapest determines regularly the composition of incinerated municipal solid waste (MSW), therefore the fossil carbon fraction could easily be calculated with the help of Table 2.4 of the 2006 Guidelines. The fossil carbon fraction of MSW changed between 12.7% and 15.5% showing a growing trend in the last five years. CO_2 emissions were estimated then with the default assumption of 100% oxidation factor. The biggest co-incinerator plant is Mátra Power Plant. Since this plant reports its verified emissions in the framework of the European emission trading, direct ETS data relating its fuel use and CO_2

emissions were taken over.
For the first time, CH_4 emissions from waste incineration have been added to the inventory. Using the default emission factors (30 kg/TJ) from Table 2.2 of the 2006 Guidelines (Chapter 2: Stationary Combustion), the resulting emissions are not significant at all. The same can be stated about N_2O emissions that were estimated the same way with the default emission factor of 4 kg/TJ.
All in all, waste incineration contributed 250-350 Gg CO_2 eq to GHG emissions in this category recently.

3.2.6.6. Source-specific planned improvements

3.2.7. Manufacturing Industries and Construction (CRF sector 1.AA.2.)

3.2.7.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2
Emission factors: D, CS, CR, PS
Key source: Level and Trend: Iron and steel, CO_2; Non-ferrous metals, CO_2; Chemicals, CO_2; Food processing, beverages and tobacco, CO_2; Other, CO_2

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) was also calculated here between 1985 and 2005. Special attention was paid to avoid double accounting. In the O*ther* subsector (1.AA.2.F) emissions from all the sectors that are not included in the previous listing (A to E) are calculated.
These include:

- Mining and Quarrying
- Manufacture of electrical 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

Emissions in the *Manufacturing Industries and Construction Sector*

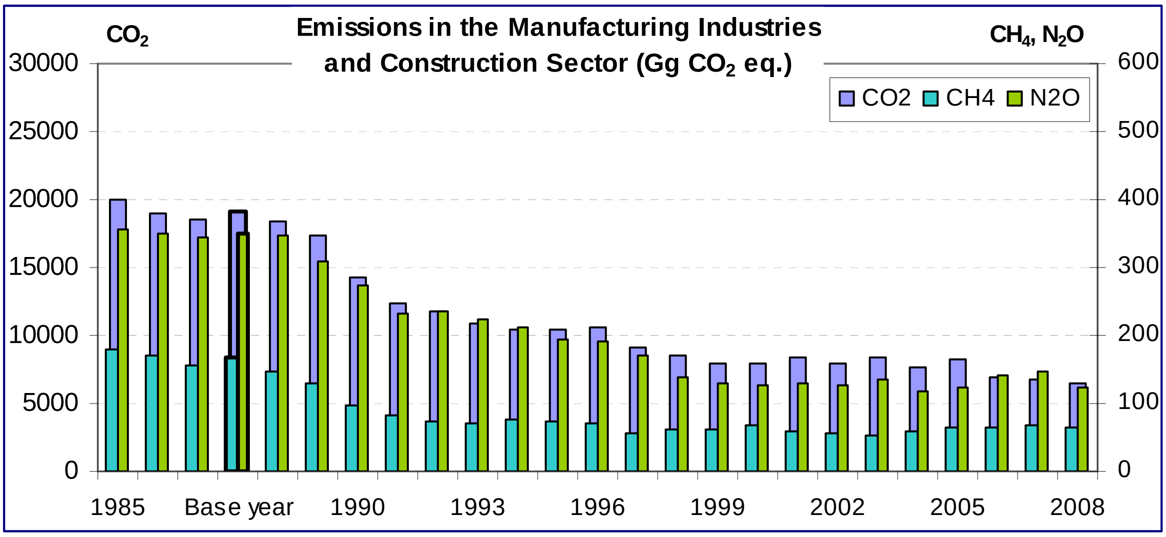


Figure 3.10. *Trends of CO_2, CH_4 and N_2O emissions in the Manufacturing Industries and Construction Sector (1985-2008)*

3.2.7.2. Methodological issues

Activity data

The energy consumption data were also calculated on the basis of the national energy balance prepared by Energy Centre. The calculation method and the associated problems are the same as those described under the *Energy Industries* (see 0).
Figure 3.11 illustrates the energy consumption of the sector. After 1990, following the economic changes, the quantities of fuels used has been significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data presented in the *Industrial Processes Sector* (*Chapter 4*). In 2005 the higher 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. Growing biomass use has become popular especially for the last three years, like in the energy industries sector. Combustion of oil products continues to lose in its weight among fossil fuels.

For the first time feedstocks and non-energy use of liquid fuels were removed from the *Chemicals* subsector for the entire time-series, now the CO_2 emission originated from non-combustion processes can be found in the *Industrial Processes Sector*.

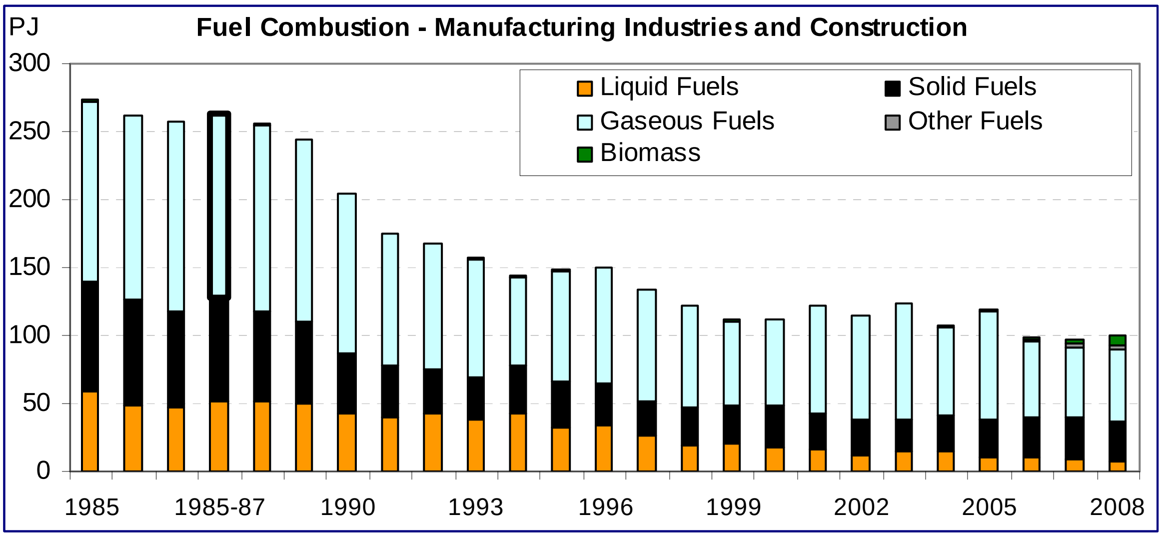


Figure 3.11. *Fuel combustion in the Manufacturing Industries and Construction Sector (1985-2008)*

The sudden decrease of the solid fuel CO_2 IEF for iron and steel between 2005 and 2006 is due to the coke oven gas consumption. This type of fuel has very low CO_2 emission factors (see *Table 3.4*). Coke oven gas has been combusted by this company for several years, but the main activity and structure of the company has changed during the past 24 years and the statistical allocation has also changed during the time-series. We would like to revise the allocation of fuels if we got more detailed dataset for the entire time-series.

Emission factors

Mainly default CO_2 factors are used in this sector. There are only two exceptions, namely the coke oven coke and coke oven gas combusted by the iron and steel industry, where measured (by accredited laboratory) carbon content of fuels were available from the EU ETS. According to the measurements the carbon content of coke oven gas and coke oven coke are 11.5 t C/TJ and 29.2 t C/TJ, respectively.
Other GHG 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 Hungarian expert 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 3.7. *Country specific emission factors for CH_4 and N_2O in manufacturing industries and construction*

3.2.7.3. 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%.
The time-series data is not consistent, because energy consumption of the *manufacturing of solid fuels* is calculated only for the 2006-2008 period in the *Energy Industries* subsector, before that time it is included in the *Chemicals* and *Other Industry* categories.

3.2.7.4. Source-specific QA/QC and verification

Energy consumption data were subject of several rounds of verification before use.
Verified energy use from EU ETS was compared to the statistical data. It was noticed that data in metric tonnes are similar in the ETS to those in the statistics, but there are some differences in energy values due to different NCVs.

3.2.7.5. Source-specific recalculations

For the first time, feedstock and non-energy use of liquid fuels were removed from the *Chemicals* subsector for the entire time-series. Now, the CO_2 emission originated from non-combustion processes can be found in the *Industrial Processes Sector*.
Emissions from bitumen used as feedstock for asphalt roofing and road paving with asphalt are moved to 2.A.5 and 2.A.6 sectors, however their CO_2 emissions were never calculated according to the methodology of the IPCC 1996 and 2000 guidance.
The other feedstock and non-energy products are reported under 2.G in two aggregated categories, because the exact place of conversion of feedstock within the chemical industry is not known – presumably it is confidential data. The same aggregation was applied for non-energy use of fuels.

Part of the emissions from waste incineration for energy purposes was re-allocated to this source category. This was possible by using data from the Hungarian Waste Management Information System that contains among others plant-specific data according to business activities in a NACE-code like classification system.
Emissions were calculated the same way as described in Ch. 3.2.6.5. First, amount of waste had to be converted to energy units, then the fossil carbon fraction had to be determined based on waste composition data. Special attention was given to the four big cement factories, as they incinerate large amount of waste of fossil origin (plastics, rubber etc.). Their verified ETS data (emissions and fuel use) were analyzed, from which a specific emission factor was derived: 2.2 tonne CO2 / tonne fossil waste. This EF was used for the years 2004 and 2005 in case of fossil wastes. From 2006 on, ETS data (fuel consumption and emission) of the cement factories were used directly. It could be seen that the other industrial facilities incinerate predominantly waste of biogenic origin, mostly wood waste, therefore their CO_2 emissions did not contribute to the national total. The insignificant CH_4 and N_2O emissions were estimated for all waste (not only fossil but also biogenic) using the default emission factors of 30 kg/TJ and 4 kg/TJ, respectively.
All in all, waste incineration contributed around 100 Gg CO2 eq. to the emissions of this source category. It must be noted, however, that by using ETS data, total emissions from waste incineration increased by 50-60 Gg compared to previous estimations.

3.2.7.6. Source-specific planned improvements

3.2.8. Transport (CRF sector 1.AA.3)

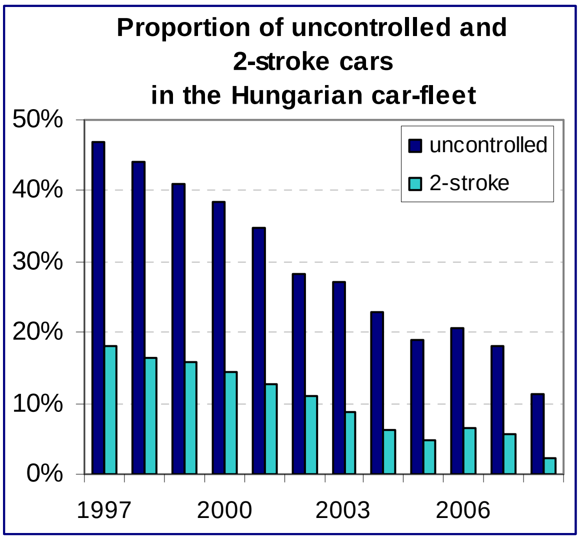
3.2.8.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1, T2
Emission factors: D, CS
Key source: Level and Trend: Road transportation, CO_2 and N_2O;
Trend: Railways, CO_2

This sector covers all the emissions from fuels used for transportation purposes. International aviation and navigation are excluded.
During the second part of the analyzed period, the composition of the national passenger car fleet underwent considerable changes. The proportion of Eastern European cars characterized by high fuel consumption decreased; currently, more than 80% of the vehicles are more advanced cars. *Figure 3.13* shows the changes in composition of the Hungarian car fleet from 1997.

Electrification of the railways in Hungary decreased the solid fuel consumption by 99.5%. Today there are only few lines – non-scheduled –, which use steam engines.
Emissions were calculated from the national fuel consumption data published in Energy Statistics Yearbook (1985-2009).

National statistics usually does not 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). This year the aviation gasoline and the used amount by navigation are included under road transport.



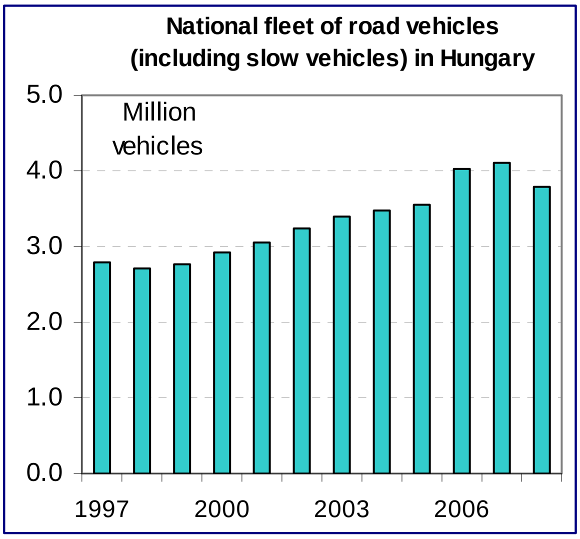


Figure 3.12. *Proportion of the uncontrolled and 2-stroke cars in the Hungarian car fleet (Source: KTI (2006), HCSO (2006), Delta Informatika Zrt (2007-2008))*

Figure 3.13. *National fleet of road vehicles in Hungary, 1997-2007 (Source: HCSO (1998-1999), Delta Informatika Zrt (2000-2008)*

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:

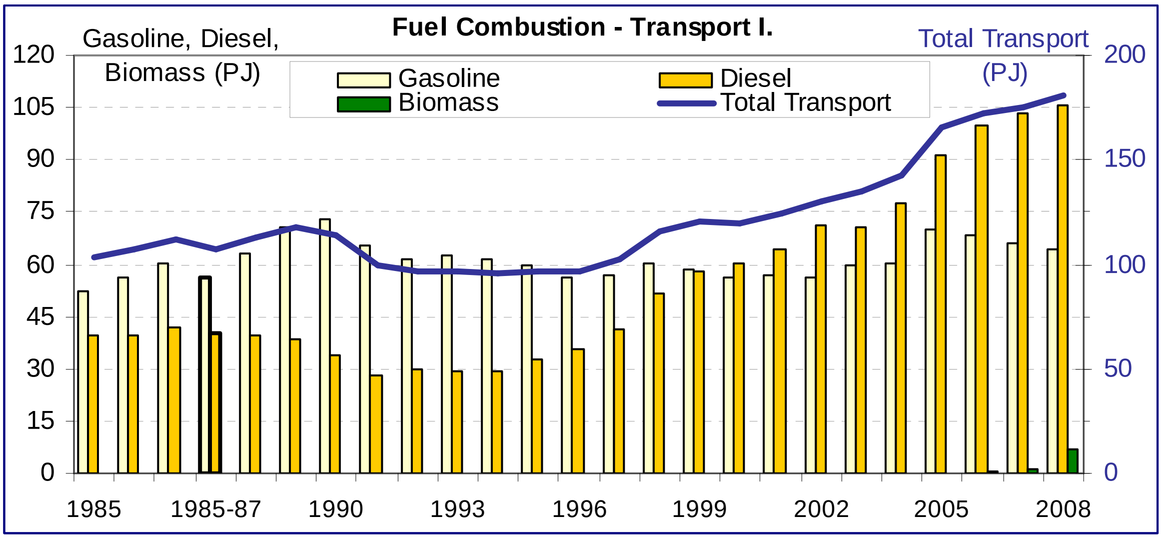


Figure 3.14. *Gasoline, diesel and biomass consumption and total energy use in the Transport Sector (1985-2008)*

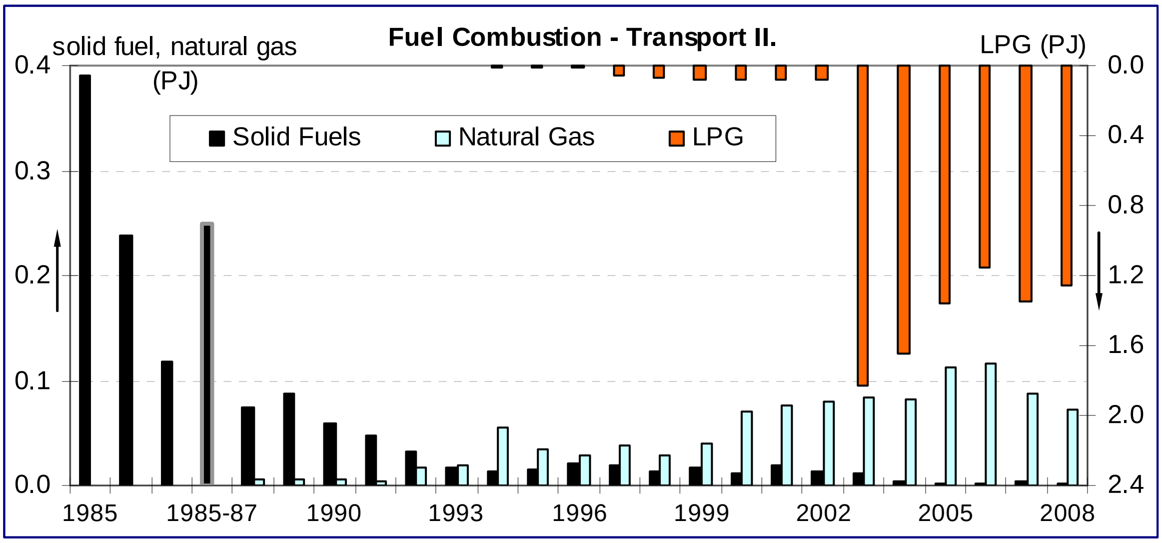


Figure 3.15. *LPG, natural gas and solid fuel combustion in the Transport Sector (1985-2008)*

Figure 3.14. clearly shows that in contrast to the other described sectors, transport consumption shows a rising overall tendency. In the second half of 2005 the Hungarian oil and gas company's refinery, MOL Danube Refinery, started to process bioethanol from vegetable raw material with high sugar content, also biodiesel have been used for blending. These bio components appeared in *Figure 3.14* and their use is remarkably growing year by year.

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 statistics. 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 3.2.9*).

Emissions in the *Transport Sector*

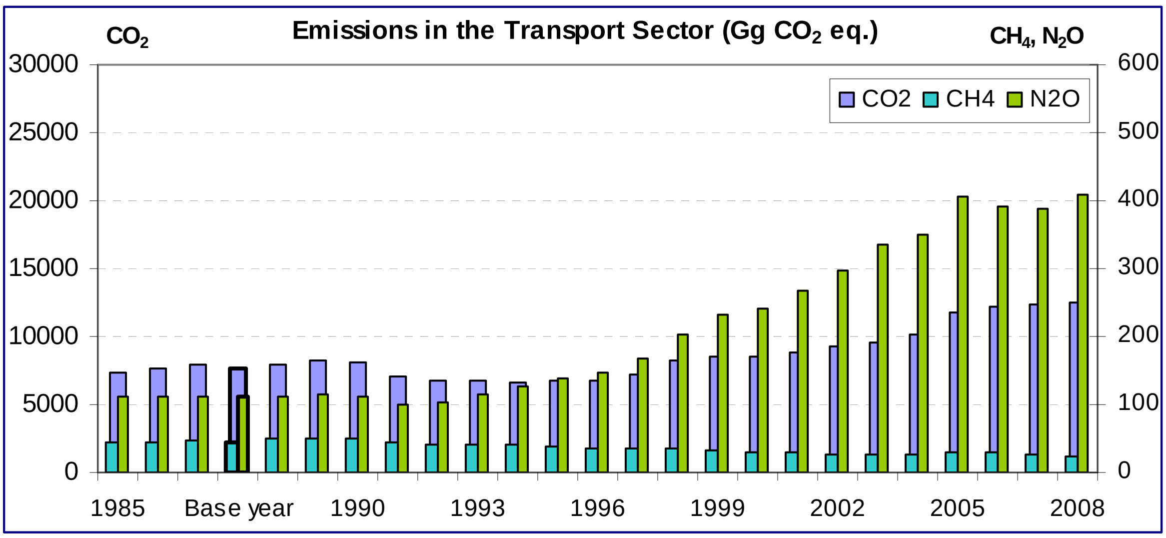


Figure 3.16. *Trends of CO_2, CH_4 and N_2O emissions in the Transport Sector (1985-2008)*

3.2.8.2. Methodological issues

CO_2 emission from transport is calculated by multiplying fuel consumption taken from Energy Statistics Yearbooks (1985-2008) by the default IPCC emission factors.

Calculation of CH_4 and N_2O emissions from road transport was changed last 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 (HCSO, 1985-2008) and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet (*Figure 3.12*).

For the base years it was assumed that passenger cars with 2-stroke engine have same the share in traffic like other gasoline vehicles. This assumption can be applied in the early 1990s, too. For the last few years, data about the use of cars with 2-stroke engine were obtained from KTI (Institute of Transport Sciences) reports and personal communication with experts.

It should be noted that unleaded gasoline was sold after 1989 (*Figure 3.17*). Since lead is poison for catalytic converters, catalyst vehicle has been used after this time.

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-3 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 the European Union, as well in Hungary.

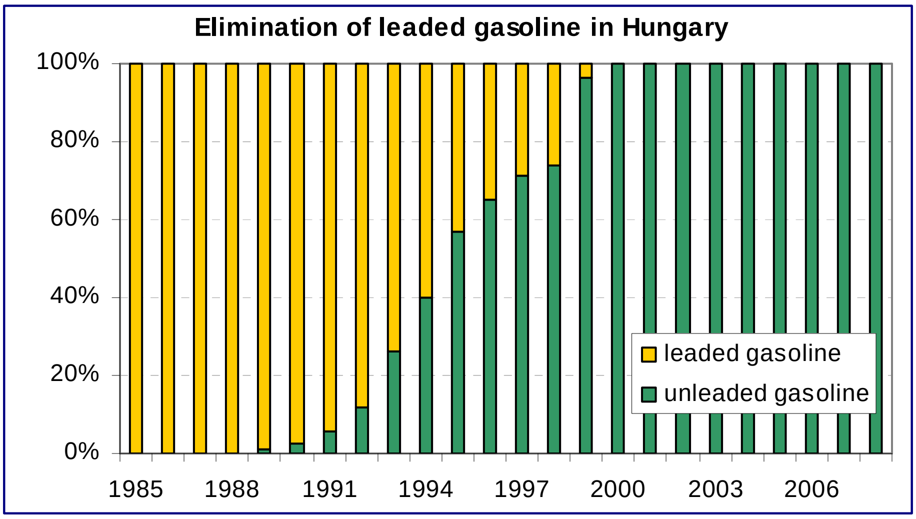


Figure 3.17. *Elimination of leaded gasoline in Hungary*
(Source: Hungarian Petroleum Association (MÁSZ), Annual Reports 1996-2008)

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	Brown Coal	26.2	Revised 1996 Guidelines, Table 1-2
Gaseous fuels	Natural Gas	15.3	Revised 1996 Guidelines, Table 1-2

Table 3.8. *CO_2 emission factors in the Transport Sector*

Methane and nitrous oxide emission factors for road transport are summarized in *Table 3.10* and for railways and navigation are shown in the following table (*Table 3.9*). Emissions from in-country aviation, which represent a very low proportion, were taken equal to the emission from consumption of aviation gasoline, and calculated in those years when the related data were available in the energy balance. Where aviation gasoline was not indicated in a separate line, consumption and emissions are calculated together with road traffic gasoline.

3.2.8.3. 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%).

Category	Fuel type	Emission factor (kg/TJ)	
		CH_4	N_2O
Railways	Liquid fuels	3.5	6.0
	Solid fuels - Brown coal	80.0	12.0
Navigation	Gas/Diesel Oil	5.0	5.0
Civil aviation	Aviation Gasoline	0.5	2.0

Table 3.9. *CH_4 and N_2O emission factors in the Transport Sector (excluding road transport)*

3.2.8.4. Source-specific QA/QC and verification

LPG consumption was double counted for 2000, because the fuel consumption was also taken into account in the *Residential Sector*, this correction affected only the emission in residential sector.

Emission factor of EURO-3 and EURO-4 gasoline passenger cars were checked and corrected for the whole time-series.

Categorization of gasoline and diesel heavy and light duty vehicles was revised, and CH_4 and N_2O emissions were recalculated for 2004 to 2007.

3.2.8.5. Source-specific recalculations

The ERT noted that the time series for the N_2O and CH_4 IEF for gasoline and diesel used in road transportation are not consistent for the years 1988-2003. We stated in the 2008 submission that we are waiting for more information to correct the emissions data for previous years. There were no changes in this category in the last submission, so the ERT reiterated the recommendation of the previous review that we shall update the entire time series for gasoline and diesel used in road transportation. The ERT encourages to use the recalculation approaches suggested by the IPCC good practice guidance (e.g. trend extrapolation), until better data are available. In this submission the recalculated time-series for the N_2O and CH_4 for the mentioned categories are reported. Since the appropriately detailed datasets are still missing, it was decided to fill the gap with the help of existing datasets and background information (e.g.: consumption of gasoline types). The generated emissions for the missing years fit in well with the trend of implied emission factor, however it is expected that these results will be refined in the future.

During the review the ERT noted inconsistencies in the aviation gasoline EF for the entire time series. It was corrected for those years, where activity data was available.

3.2.8.6. Source-specific planned improvements

None.

Table 3.10. *CH_4 and N_2O emission factors in the Road Transport Sector*

** 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*

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-3	4.0	6.0	8.5	Expert judgement using IPCC, 2006 Guidelines, V2 Table 3.2.3
		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
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.

3.2.9. Other Sector (CRF sector 1.AA.4)

3.2.9.1. Source category description

Emitted gases: CO_2, CH_4, N_2O
Methods: T1
Emission factors: D, CS, CR
Key source: Level and Trend: Commercial/institutional, CO_2; Residential, CO_2; Agriculture/Forestry/Fisheries, CO_2

This sector covers combustion in public institutions, by the population and in the *Agriculture/Forestry/Fisheries Sector*.

Emissions in the *Other Sector*

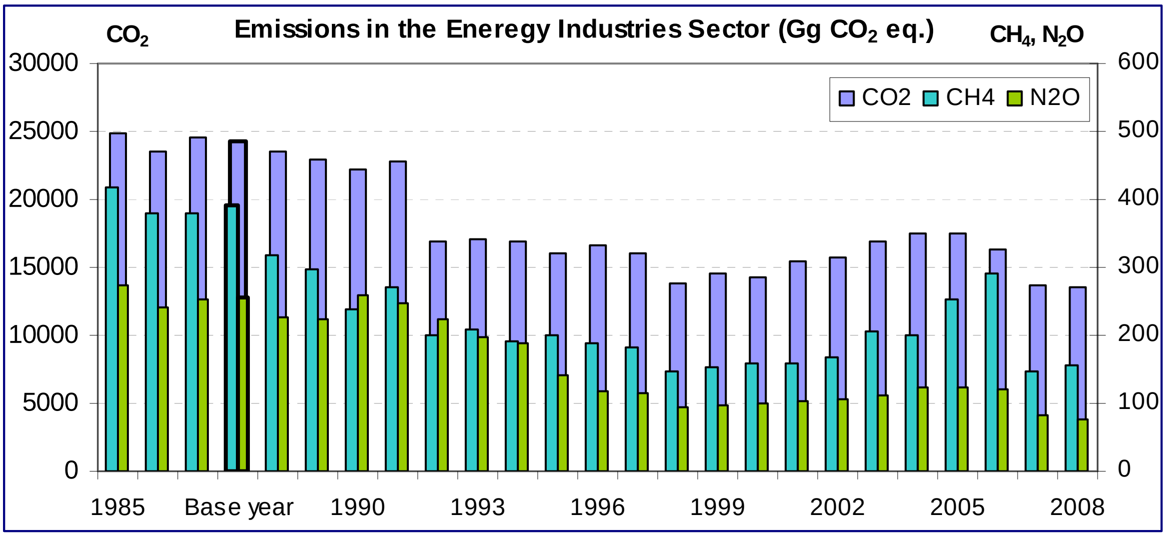


Figure 3.18. *Trends of CO_2, CH_4 and N_2O emissions in the Other Sector (1985-2008)*

HDD and energy demand of the *Residential Sector*

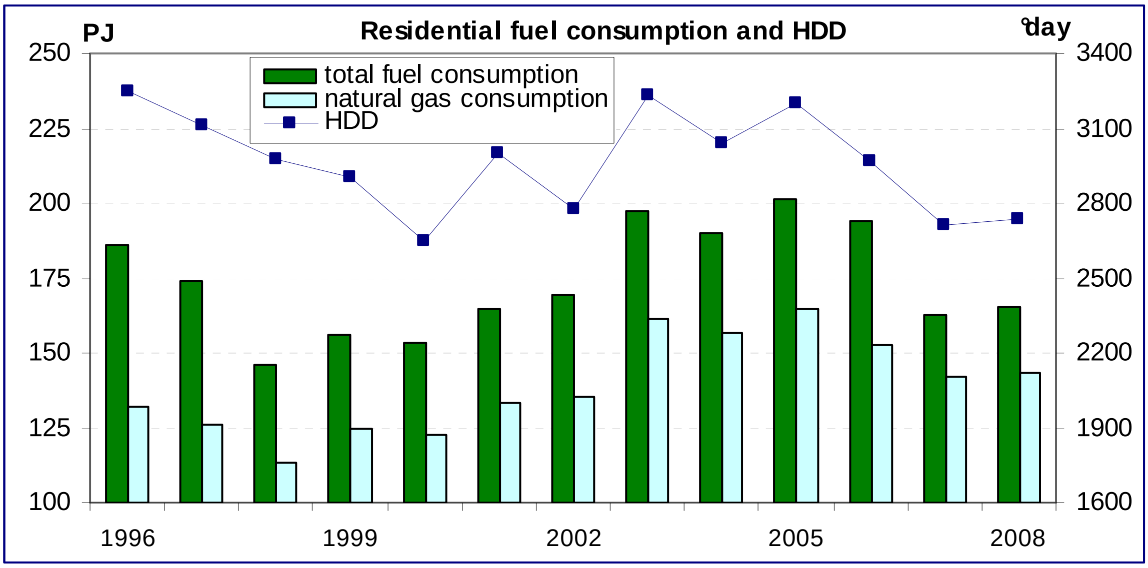


Figure 3.19. *Comparison of residential fuel consumption and HDD between 1996 and 2008*

Heating degree day (HDD) is a quantitative index which reflects demand for energy to heat houses and businesses. This index is derived from daily temperature observations. The inside temperature is 18℃ and base temperature (the outside temperature above which a building needs no heating) is 15℃ in our calculation (following the standard European methodology). *Figure 3.19* illustrates the relationship between residential fuel consumption and HDD. Line of HDD and fuel consumption bars are running parallel, especially in the last 6-7 years.

3.2.9.2. Methodological issues

Activity data

Activity data was obtained from energy statistics as described in the introduction section of the chapter (*Section 3.1*). *Figure 3.20* illustrates the fuel consumption of the sector by types.

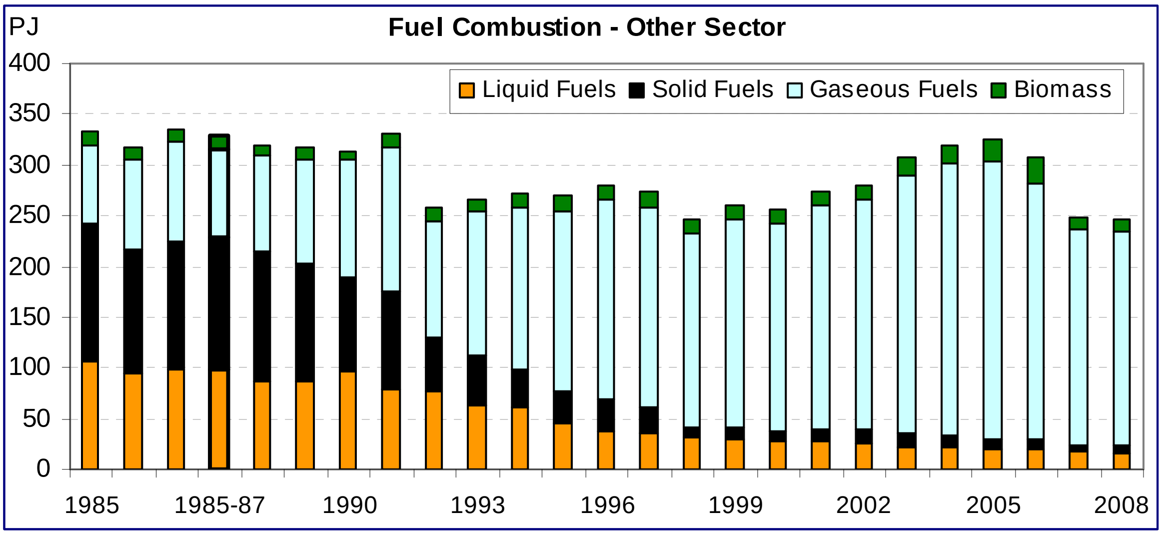


Figure 3.20. *Share of different combusted fuel types in the Other Sector (1985-2008)*

Since 59-74% of the fuel consumption is related to the *Residential Sector*, the fuel structure is influenced principally by the changes in this sector. In contrast with the significant reduction of coal and oil consumption, natural gas consumption has increased significantly. During the period 1985-2008 natural gas transmission pipelines length has doubled (see Table 3.18), and the number of households supplied with natural gas has been increasing continuously, which is illustrated by the length of the distribution pipelines. Population switched from coal to natural gas combustion. Household heating oil was completely replaced by LPG during the last years of the analyzed period, as shown in *Table 3.11*, but consumption of the total liquid fuels has been decreased significantly caused by the spread of natural gas supply.

Sector	Fuel consumption (TJ)	2000	2003	2004	2005	2006	2007	2008
Commercial/ Institutional	Oil	1,127	366	744	289	41	325*	36*
	LPG	2,131	1,739	1,643	1,609	1,595	1,399	896
Residential	Oil	54	0	0	0	0	0	0
	LPG	12,091	9,353	8,836	6,688	6,890	3,943	3,673

Table 3.11. *Oil and LPG consumption in the Commercial/Institutional and Residential Sectors in selected years after 2000*

** without transport, storage and communication*

As the dominant fuel is natural gas in the *Other Sector*, the following basic statistical data will help to get acquainted with the Hungarian situation (source: HCSO, 2009).
Residential and Commercial/ Institutional consumption represented 58% of total natural gas consumption (transported by pipelines) in 2008. 91,1% of the settlements were supplied with this facility in 2008. Some 84% of households use natural gas for heating purpose as well. Sold natural gas for residential consumer increased by less than 1% in 2008 compared to 2007, because the winter period (see *Figure 3.21*) was somewhat warmer than in the previous year and consumer price index of natural gas increased significantly. After 1990 individual residential heating became widespread, but still more than 15% of dwellings (of which 37% exists in the capital city) are supplied with district heating based also mainly on natural gas – this emission was calculated under the *Energy Sector*.

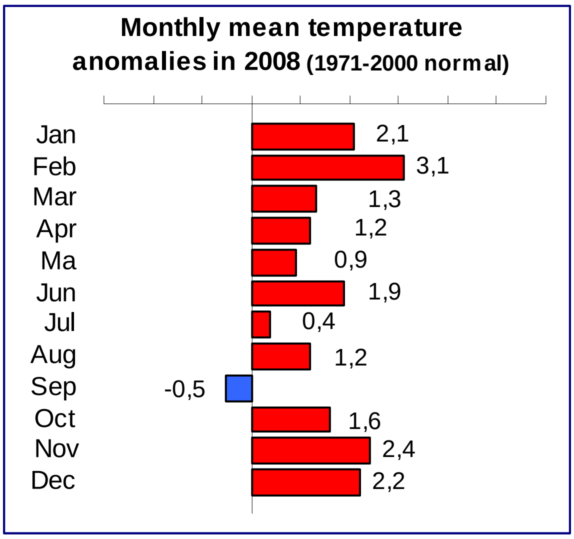


Figure 3.21. Monthly mean temperature anomalies in 2008 (1971-2000 climatical average)

Annual mean temperature was 1.5℃ higher in 2008 compared to 1971-2000 climatical average and -0.2℃ lower than in 2007, also the heating period was slightly cooler than in 2007; but the total fuel consumption of the *Other Sectors* decreased by 0.4% compared to 2007. Budapest Gas Works Plc. have established that in the previous two years (2007 and 2008) the residential gas consumption dropped by 7-8% (after weather correction) in the capital city, which is the joint impact of the following factors: more expensive tariff, modern heating systems and insulations.

The consumption rates of the subsectors are shown in Figure 3.22.

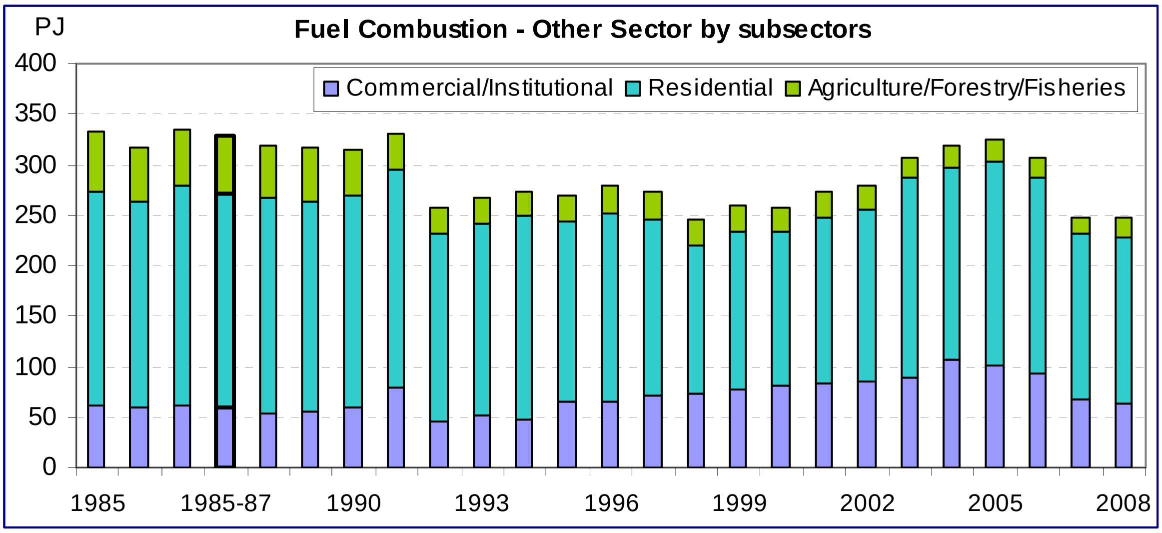


Figure 3.22. *Fuel combustion in the subsector of the Other Sector (1985-2008)*

Emission factors

Default emission factors for CO_2 are used for liquid and gaseous fuels and for most of the solid fuels. The only exception is the residential lignite emission factor, which is the same as

described in *Section 0 Table 3.4*, because the power plant, which reported the measured carbon content of lignite, sold directly this amount to the consumers.
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.
Due to the relatively high briquette consumption in the agriculture, the used average factor for solid fuels is lower than in the other sectors.

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*

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 in the 2008 submission according to the suggestion of UNFCCC expert review team. 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*

3.2.9.3. 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 processes 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.

3.2.9.4. Source-specific QA/QC and verification

LPG consumption was double counted for 2000, because the fuel consumption was also taken into account in the *Transport Sector*, this correction affected only the emission in the *Residential Sector*.

3.2.9.5. Source-specific recalculations

Activity data were corrected among final consumers for gaseous fuels in the energy sector for 2007. This change affected the petroleum refining and residential sectors. The corrected fuel consumption in residential sector was harmonized with the fugitive emission from distribution as well and this increased slightly the total emissions of the energy sector.

3.2.9.6. Source-specific planned improvements

We stated in previous submission, that it is planned to investigate the relation of fugitive emission from natural gas pipelines and emission from *residential* and *commercial/institutional* natural gas consumption. This revision is in progress.

3.3. Fugitive emissions from solid fuels and oil and natural gas (CRF sector 1.B)

3.3.1. Solid fuels (CRF sector 1.B.1)

3.3.1.1. Source category description

Emitted gas: CH_4
Methods: D, T2
Emission factors: CS
Key source: Trend: Solid Fuels, CH_4

This category includes fugitive CH_4 emission released during coal mining and handling. 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 14% today. Drastic reduction in coal production was observed between 1987 and 1988, as well as between 1989 and 1990 (see *Table 3.14*). Underground mining continues to decrease in both relative and absolute terms, therefore distribution of mined coal types underwent significant changes (*Figure 3.24*).

Fugitive emissions from solid fuels

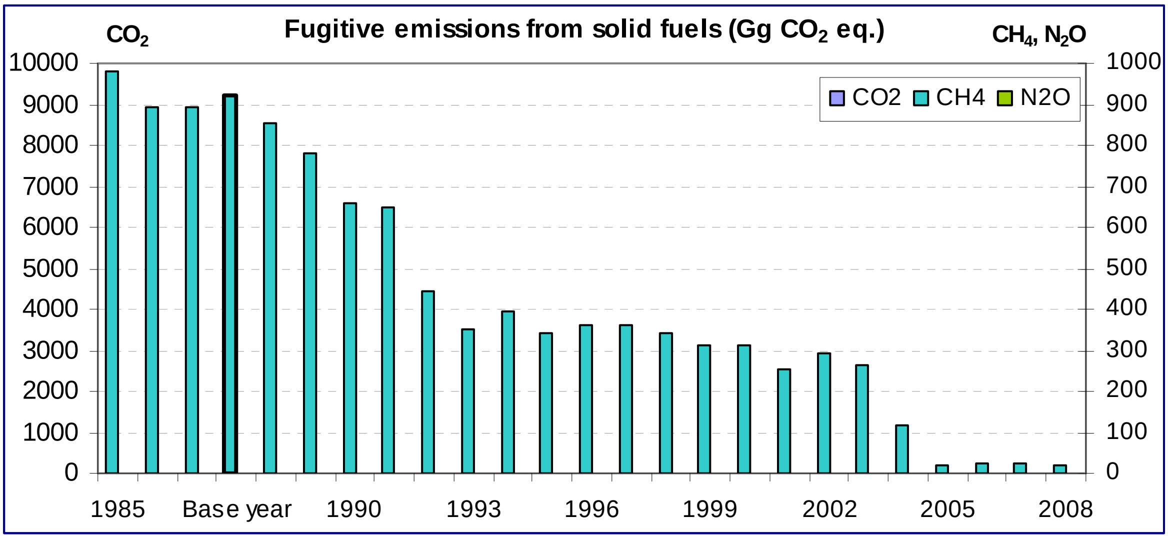


Figure 3.23. *Trends of CO_2, CH_4 and N_2O emissions from solid fuels (1985-2008)*

3.3.1.2. Methodological issues

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.

Year	1985	1986	1987	1990	1995	2000	2005	2006	2007	2008
Coal production (10^6 t)	24.04	23.13	22.84	17.66	14.59	14.03	9.57	9.95	9.82	9.40

Table 3.14. *Coal production of selected years in Hungary*

Activity data

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

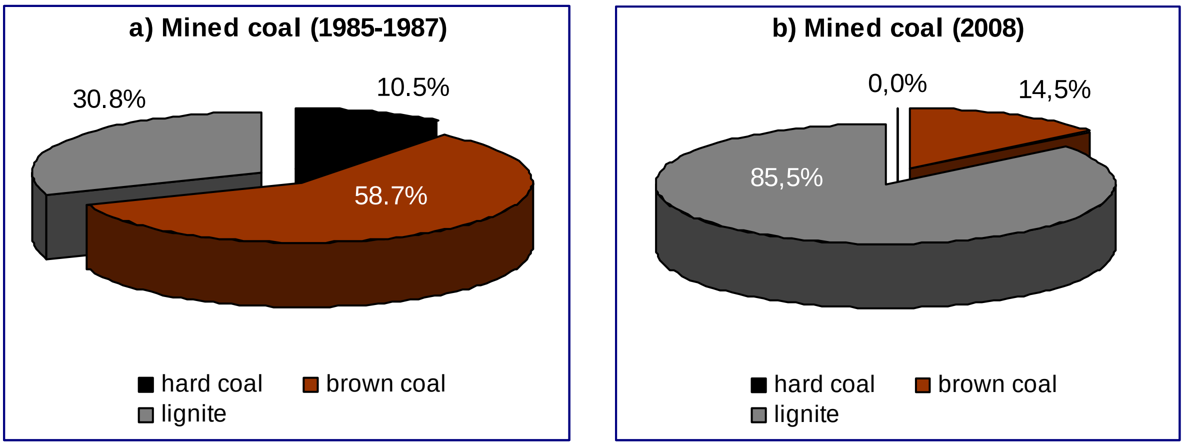


Figure 3.24. *Distribution of mined coal in the base year (a) and 2008 (b)*

Hungarian mines are not drained. There are no mine-burning or burning coal waste piles. From the older coal waste piles the combustible part has been extracted for decades. Abandoned mines are gobbed and are flooded with water – based on the information of the Mining Property Utilization Company in the Public Interest –, therefore methane emission can be negligible.

Emission factors

Emission factors were taken into consideration according to the information from Mining Bureau of Hungary and measurement 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.

Table 3.15 shows the measured methane content of coal for the active mines in Hungary in the last few years. Mine of Lencsehegy closed in 2004, previously it had been producing significant amount of coal having 0.0 m^3/t methane. In 2008 the only one operating mine was Márkushegy with 0.93 m^3/t in-situ methane content. Lignite is mined only in surface mines; where – 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).

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))

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 the value of mining factor. The new emission factors are lower than the default ones.

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*

3.3.1.3. Uncertainties and time-series consistency

The uncertainty of this source category is originated from the categorization of activity data and use of measured emission factors. The combined uncertainty of the sector is approximately 10%.

3.3.1.4. Source-specific QA/QC and verification

3.3.1.5. Source-specific recalculations

3.3.1.6. Source-specific planned improvements

It is planned to separate the amount of mined brown and hard coal to underground and surface types. This new categorization will reduce the methane emission and also the uncertainty of the sector in some extent.

3.3.2. Oil and natural gas (CRF sector 1.B.2)

3.3.2.1. Source category description

Emitted gas: CO_2, CH_4, N_2O
Methods: D, CS
Emission factors: D, CS, OTH
Key source: Level and Trend: Oil and Natural Gas, CH_4

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.

Fugitive emissions from oil and natural gas activities

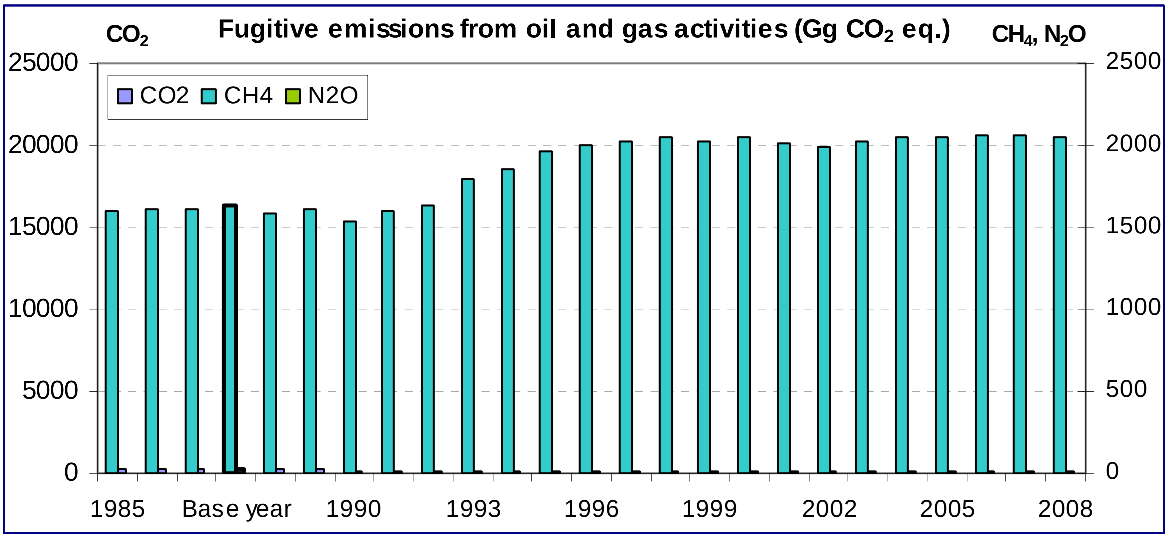


Figure 3.25. *Trends of CO_2, CH_4 and N_2O emissions from oil and natural gas activities (1985-2008)*

3.3.2.2. Methodological issues

Activity and consumption data related to extraction and primary handling were taken from Energy Statistics Yearbook. In addition, data from the HCSO 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).

CH_4 and N_2O emissions from flaring (oil and gas) are included for the first time, in this submission.

Pipeline length (km)										
Year	1985	1986	1987	1990	1995	2000	2005	2006	2007	2008
Transmission	3,544	3,681	3,889	4,046	4,684	5,767	5,193	5,206	5,207	5,261
Distribution	10,262	12,474	14,200	22,559	53,436	72,540	80,519	81,033	81,555	82,128

Table 3.18. *Annual data for natural gas pipeline lengths in selected years*

3.3.2.3. 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.

3.3.2.4. Source-specific QA/QC and verification

3.3.2.5. Source-specific recalculations

3.3.2.6. Source-specific planned improvements

3.3.3. Other fugitive sources related to oil and natural gas activities (CRF sector 1.B.2.D)

3.3.3.1. Source category description

Emitted gas: CH_4
Methods: CS
Emission factors: CS
Key source: -

This category 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.

3.3.3.2. Methodological issues

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 among fugitive emissions from oil and natural gas *(1.B.2.D Other)* 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 or fuel production.

3.3.3.3. Uncertainties and time-series consistency

3.3.3.4. Source-specific QA/QC and verification

3.3.3.5. Source-specific recalculations

3.3.3.6. Source-specific planned improvements

It is planned that these emissions will be analyzed 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.

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4. INDUSTRIAL PROCESSES (CRF sector 2.)

4.1. Sector Overview

Industrial Processes sector includes emissions generated by non-firing processes related to industrial production. Emissions from the industrial processes are the third largest following the energy and agriculture sectors (see *Figure 2.7.* in Chapter 2).
Emissions from this category comprise the following sub categories: Mineral Products (CRF 2.A.), Chemical Industry (CRF 2.B.), Metal Production (CRF 2.C.), Other Production (CRF 2.D.), Consumption of Halocarbons and SF_6 (CRF 2.F.) and Other (CRF 2.G). Under Mineral Products Hungary reports the emissions from cement production (CO_2, SO_2), lime production (CO_2), limestone and dolomite use (CO_2), asphalt production (CO, NMVOC), glass (CO_2, NMVOC), bricks and ceramics production (CO_2). Under Chemical Industry emissions from ammonia (CO_2, CO, NMVOC, SO_2), nitric acid (N_2O, NO_X, CO_2), and other chemical production (CH_4, NMVOC, SO_2), for example carbon black and ethylene are reported. Under Metal Industry emissions from pig iron (CO_2, CH_4), steel (CO_2, CH_4) ferroalloys (CO_2), aluminium (CO_2, CF_4, C_2F_6, NO_X, CO, SO_2) are taken into account. Consumption of halocarbons and SF_6 means emissions from different source, for example: refrigeration, air conditioning equipment, foam blowing, aerosols, electrical equipment. The 2.G sector contains emissions from non-energy use of fuels and feedstock (CO_2).
The base year is the average of 1985–1987 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6.

Figure 4.1 shows the main sources of greenhouse gas emissions:

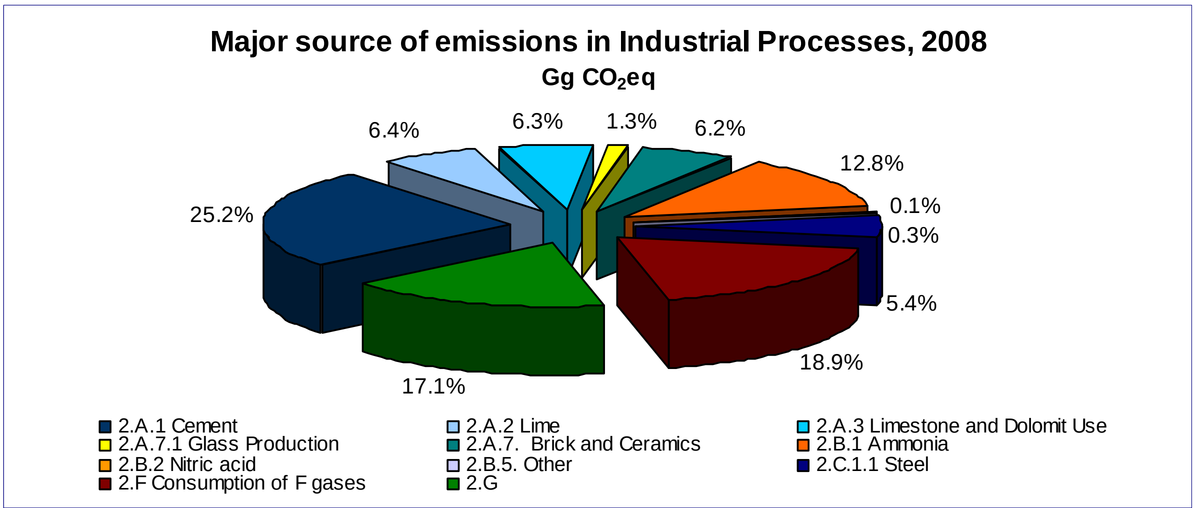


Figure 4.1. *The major processes in Industrial sector, 2008 (Gg, CO_2 eq)*

4.2. Emission Trends

Total emissions estimated from industrial processes were 5,001.77 Gg CO_2eq in 2008, or 6.79% of the total national emissions compared to 9.0% in the base year. Total sectoral emissions decreased by 56.1% between the base year and 2008, and by 20.6% between 2007 and 2008.
Greenhouse gas emissions from the industrial processes sector fluctuated slightly in the beginning of the inventory period, then a considerable decline happened: emissions reached their minimum in 1992, which was mainly due to economic crisis. Later on, emissions had been fluctuating again until 2005. Since then, emissions have been showing a decreasing

tendency again. *Figure 4.2*. shows the trend of GHG emissions from this category for 1985-2008.

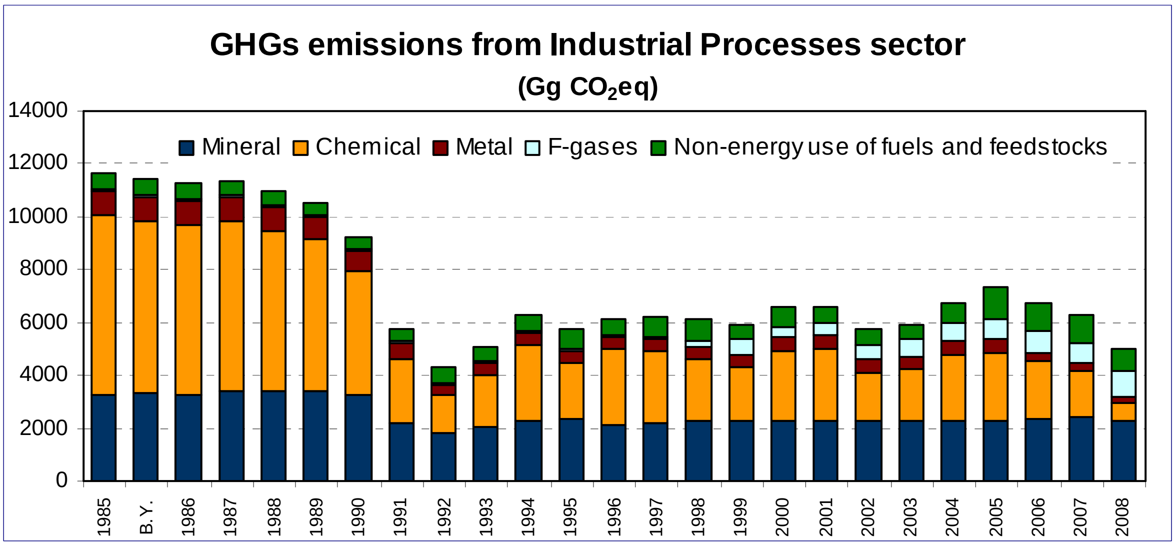


Figure 4.2. *GHGs emissions from Industry sector, 1985-2008 (Gg CO_2eq)*

The significant decrease of emissions in the period between 1989 and 1993 is strongly represented in the above figure. The reason for that is the economic transition mentioned already in previous chapters. In the course of transition, factories were closed down, capacity utilization was reduced, consequently the production decreased more or less drastically in each industrial sector.
Some examples:

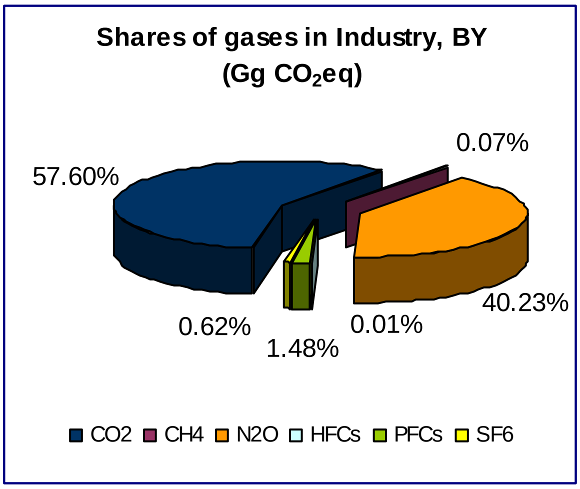
- Cement production: two plants were closed;
- Iron and steel production: two out of three plants were provisionally closed down;
- Aluminium: two out of three plants were closed down in 1991 and the aluminium production stopped in 2006 eventually;
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed down (1988, 1991 and 1995).

The privatization was slower in the industry than in other areas of the economy. Foreign investments were made rather in medium or smaller sized enterprises than in the big companies of the Hungarian industry.
One of the reasons of temporary production decrease was the modernization process of the remaining factories which was carried out that time and which by the way lead to favourable changes of specific emission factors as well. This was the situation e.g. in the cement and limestone industry. In some cases, however, also plants having more advantageous emission factors were closed, causing unfavorable changes in the national emission factor. This was the situation e.g. in the production of nitric acid before 1995 (see Ch. 4.2.2.).
Since the mid 1990s, emissions by industry have been showing a fluctuating behavior reflecting the actual demands of production in the national economy. An example is the (relatively) significant increase of methane emission, 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, 2006:578 kt, 2007:648 kt, 2008:606 kt).

4.2.1. Emission Trends by Gases

The most important GHG in Industrial Processes sector is carbon dioxide, contributing 80.73% to total GHG emissions in this sector in 2008, followed by hydrofluorocarbons

(HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) contributing 18.87% to GHG emissions (*Figure 4.3*). CH_4 and N_2O contributed 0.31% and 0.1%, respectively. Total sectoral emissions decreased by 56.1% between base year and 2008.



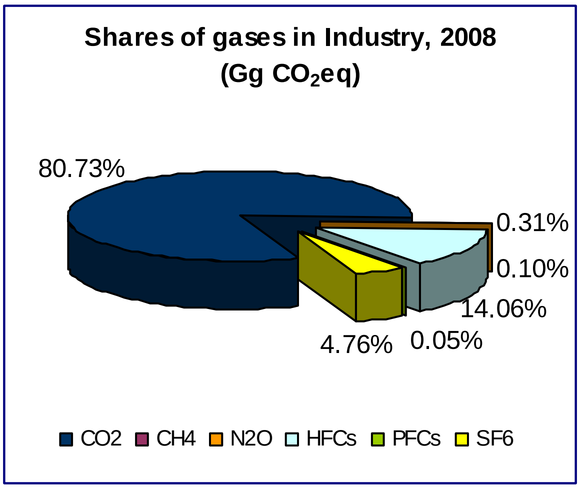


***Figure 4.3**. Shares of gases in Industry sector, in base year and 2008 (Gg CO_2eq)*

The figure below shows the emissions of this sector by gases:

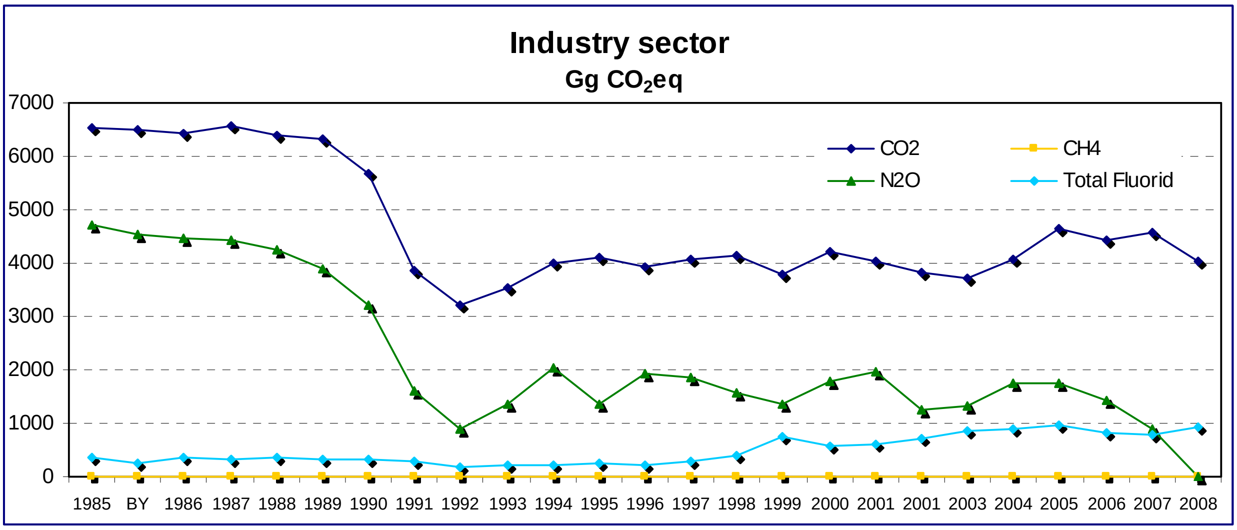
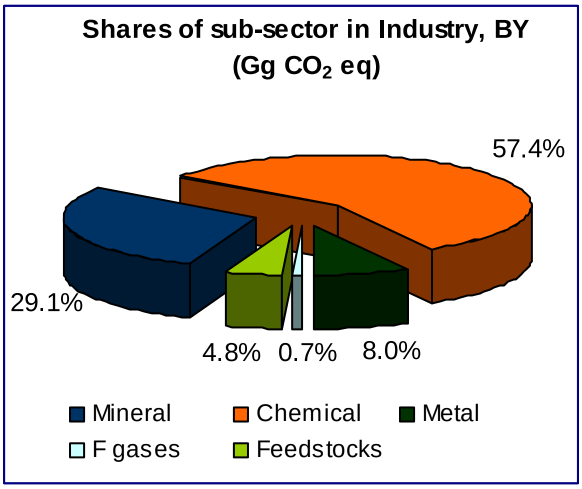


***Figure 4.4.** The most significant greenhouse gases in Industry sector. In comparison with them, the quantity of fluoride gases and methane is negligible. Note: BY=average of 1985-87 but 1995 for F-gases*

It can be seen in *Figure 4.4* that in 2008, N_2O emission from Industrial Processes are 99.89% below the level of the base year and dropped by 99.44% from 2007 to 2008 which is due to the introduction of a new nitric acid plant.

4.2.2. Emission Trends by sources

In the base year, the chemical sub-sector accounted for 57.4% of total industrial GHG emissions, followed by mineral sub-sector 29.1%, metal sub-sector 8.0% and F-gases 0.7%. In 2008 mineral sub-sector accounted for 45.4% followed by F-gases 18.9%, chemical sub-sector 13.2% and metal sub-sector 5.4% (see Figure 4.5 and *Table 4.1*.).



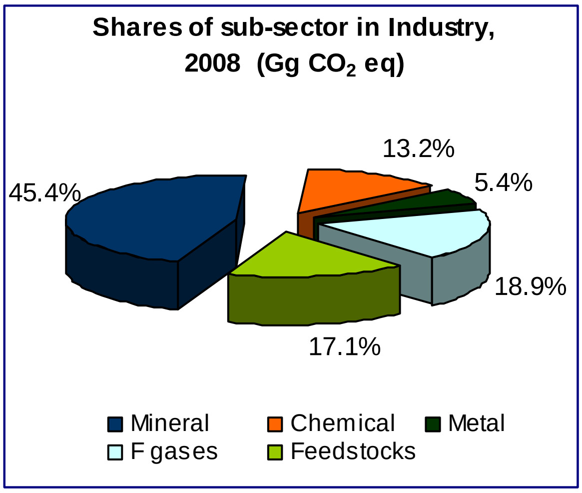


Figure 4.5. *Shares of sub-sectors in Industry sector, in base year and 2008 (Gg CO_2eq)*

Table 4.1. *Industrial processes sector CO_2eq emissions in 2008*

	GHG emissions in 2008 (Gg CO_2-eq)				
	CO_2	CH_4	N_2O	HFC/PFC/SF_6	Total
2. Industrial Processes	**4,037.77**	**15.26**	**5.08**	**943.65**	**5,001.77**
A. Mineral products	2,269.68	0	0	0	2,269.68
B. Chemical Industry	641.13	15.26	5.08	0	661.48
C. Metal Production	271.60	0	0	0	271.60
D. Other Production	0	0	0	0	0
E. Production of HFC/PFC/SF_6	0	0	0	0	0
F. Consumption of HFC/PFC/SF_6	0	0	0	943.66	943.65
G. Other	855.36	0	0	0	855.36

Figure 4.6. presents greenhouse gas emissions from Industrial Processes by sub-categories for the years 1985 to 2008. Chemical industry was the most important emitter in the beginning of the inventory period, especially N_2O emission from nitric acid production (for details see there). Nowadays the main source of greenhouse gases is Mineral Products while Consumption of Halocarbons and SF_6 is also showing a growing tendency.

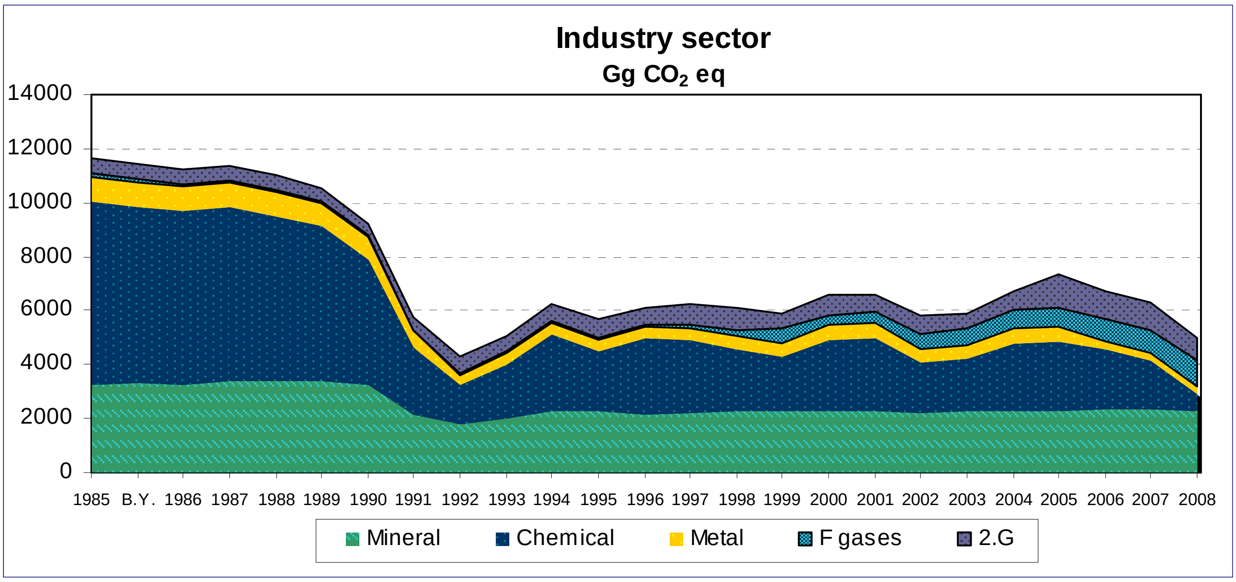


Figure. 4.6. *The emissions in Industry by sub-sectors*
Note: BY=average of 1985-87 but 1995 for F-gases.

4.3. Mineral Products (CRF sector 2.A)

4.3.1. Cement Production (CRF sector 2.A.1)

Technology

Emitted gas: CO_2, SO_2
Key source: Level 1

CO_2 is generated during cement production 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 (Calcium Oxide) and CO_2 (calcinations).

$$CaCO_3 + heat \rightarrow CaO + CO_2$$

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, only emissions from the production processes are determined. Gases originating from fuels are included in Energy sub-sector 1.A.2.B Non-Ferrous Metals.
Emissions were estimated using a country specific method similar to the IPPC Tier 2 methodology. In 2008 four factories were operating in Hungary. Production data for the whole time series were obtained directly from the factories and from the EU Emission Trading System (ETS)
According to the ETS introduced by the European Union from 2005 on, the factories report their CO_2 emission. This value is calculated on the basis of the derivatographic analysis of

carbonate, which contains also CO_2 generated from the $MgCO_3$ content of limestone. All these increase the accuracy of emission-determination. The reported quantities of CO_2 emitted between 2005 and 2008 are based on reports of the factories.
For the preceding years, raw material consumption was used for emission calculation instead of cement or clinker production. This is more accurate because cement factories measure the amount and composition of the raw flour. In 2000, production at one site was abandoned therefore previous production data of this factory were obtained directly from the Cement Industry Association that supplied only clinker data and the ratio of calcium-oxide to clinker. The table below shows the time-series of production data.

***Table 4.2**. Amount of raw flour used in process, clinker and cement production (kt) in Hungary (1985-2008)*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
Raw, kt	5,151.8	5,148.0	3,247.3	2,533.2	3,009.6	3,476.5	3,493.0	3,274.8	3,463.0	3,603.0
Clinker, kt	3,173.2	3,210.4	2,067.3	1,591.3	1,906.7	2,211.0	2,214.2	2,034.0	2,184.8	2,262.1
Cement, kt	3,888.9	3,932.8	2,563.2	2,245.6	2,521.3	2,795.3	2,874.9	2,745.0	2,806.2	2,995.1

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Raw, kt	3,617.2	3,998.1	4,008.5	4,218.3	4,209.1	3,828.2	3,578.8	3,884.3	3,938.7	3,747.0
Clinker, kt	2,270.6	2,531.8	2,522.0	2,687.1	2,696.1	2,494.8	2,352.6	2,533.1	2,577.1	2,468.4
Cement, kt	2,979.1	3,348.2	3,452.4	3,504.2	3,564.9	3,266.7	3,363.5	3,722.9	3,485.1	3,569.8

Upon receiving information on the carbonate content of the raw flour from the producers and the carbonate content of clinker from the Association, the quantity of CO_2 was calculated using the proper stoichiometric proportions. On a similar way we calculated also the amount of CO_2 generated from $MgCO_3$ using the corresponding stoichiometric ratio. The results were corrected for cement kiln dust (CKD) in the case of wet technology only. 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.

***Table 4.3.** CO_2 emissions in 2.A.1 Cement Production sub-sector (1985-2008)*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
CO_2 from $CaCO_3$, kt	1,724.0	1,752.1	1,098.0	857.2	1,019.6	1,178.3	1,182.9	1,108.6	1,171.8	1,216.7
CO_2 from $MgCO_3$, kt	54.3	45.2	28.5	26.5	31.5	36.2	35.9	34.8	36.2	36.4
Total CO_2, kt	1,741.4	1,797.3	1,126.5	883.7	1,051.1	1,214.6	1,218.8	1,143.3	1,208.0	1,253.1
	1999	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***
CO_2 from $CaCO_3$, kt	1,221.6	1,353.9	1,365.0	1,434.8	1,404.8	1,291.0	---	---	---	---
CO_2 from $MgCO_3$, kt	37.7	41.0	42.7	42.4	47.5	49.6	---	---	---	---
Total CO_2, kt	1,259.4	1,395.0	1,407.6	1,477.2	1,452.4	1,340.6	1,227.9	1,300.2	1,323.9	1,260.6

Due to the CO_2 generated from $MgCO_3$, which was calculated in 2007 for the first time for the whole time series, the earlier specific factors increased by nearly 5%. 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.
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]:

Table 4.4. *Specific emission factors of clinker and cement in 2.A.1 Cement Production sub-sector (1985-2008).*

	B Y	1990	1991	1992	1993	1994	1995	1996	1997	1998
CO_2/ clinker	0.5604	0.5598	0.5449	0.5553	0.5513	0.5493	0.5505	0.5621	0.5529	0.5539
CO_2/ cement	0.4573	0.4570	0.4395	0.3935	0.4169	0.4345	0.4239	0.4165	0.4305	0.4184
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2/ clinker	0.5546	0.5510	0.5581	0.5498	0.5387	0.5374	0.5219	0.5133	0.5137	0.5107
CO_2/ cement	0.4227	0.4166	0.4077	0.4216	0.4074	0.4104	0.3651	0.3492	0.3799	0.3531

The default factor is 0.5071 t/t for clinker (with a CaO content of 65%), and 0.4985 for cement (Revised Guidelines). The higher specific CO_2 emission of clinker is due to the higher $CaCO_3$ content of raw flour which results in better clinker quality. This enables the higher content of additives in cement and lower emission factors.

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.
Due to different measuring approaches before and after 2005, the consistency of the time-series shall be verified.

QA/QC information

The data used for emission calculations 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

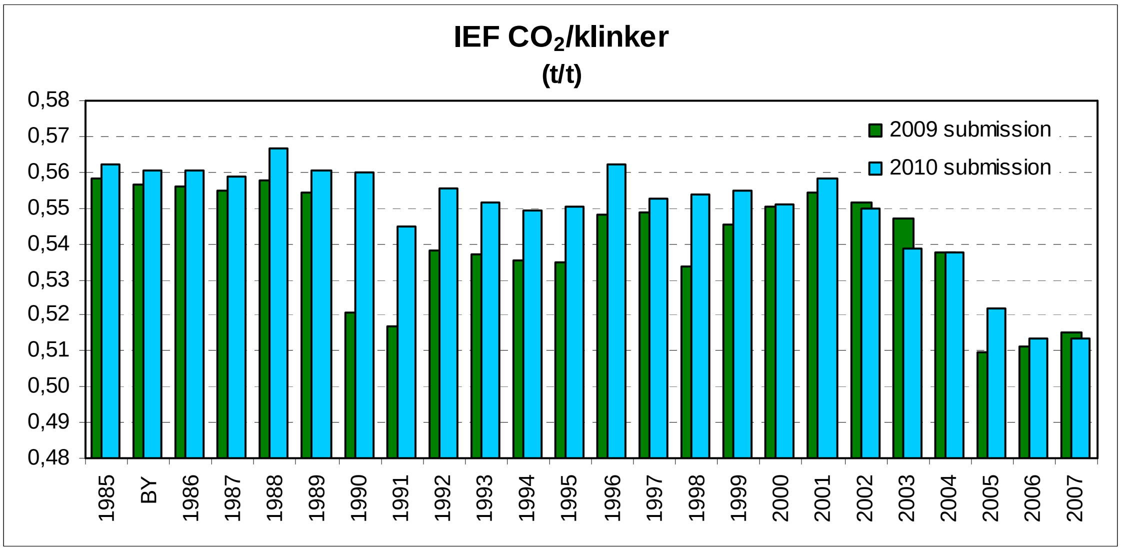
[1]The national total emission was calculated by summing the emissions of individual factories instead of using the average of the specific emissions.

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

data received from the Association and those published by KSH show a difference of a few thousand tons.
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

Activity and emission data have been updated last year. Cement plants were contacted and asked for revision of the applied activity data. Data were corrected by the quality assurances or controlling divisions of the facilities. Verified CO_2 emissions reported under the EU ETS were available for the years 2005-2008. These data were compared with each other and it came to light that data from the ETS were more accurate which was due to the fact that calculations in the ETS were based on monthly values, thus rounding error were smaller.
The figure below shows the recalculation difference of IEF CO_2/clinker compared to the previous submission.



***4.7. Figure** Implied emission factor (t/t)*

Planned improvements

None.

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

Technology

Emitted gas: CO_2
Key source: Level 1

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 is generated according to this formula. CO_2 generated by firing processes is

accounted under the Energy sector in 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 were received directly from the operators which increased the reliability of the information.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.3.3. Limestone and Dolomite Use (CRF sector 2.A.3)

Technology

Emitted gas: CO_2
Key source: Level 1

This sub-sector includes processes in which calcinations (CO_2 loss) occur as a result of heating limestone and dolomite, but excluding their use in cement and lime production. Here, only CO_2 emissions generated by the degradation reaction are calculated while 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. These values were obtained on the basis of the data received from the manufacturers. For those years when 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 when the default values were used, the uncertainty is higher.

QA/QC information

No sector-specific information is available.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.3.4. Glass Production (CRF sector 2.A.7.1)

Technology

Emitted gas: CO_2
Key source: Level 1

Although glass production is mentioned in the Revised Guidelines as a source of NMVOC only, also CO_2 emission from glass production was determined based on the data from the emission trading system. CO_2 emission is generated by adding the carbonates (mainly soda ashes) of the alkali metals (Ba, Li, Na, etc.) 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 reported by them was accepted as emissions in 2005, 2006, 2007 and 2008. The data of total produced quantity were provided by the HCSO. The CO_2 emission is only 62.98 Gg representing only 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. A specific emission factor was created from the emission trading data of 2005, and emissions were calculated retrospectively using this EF with the known production data.
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.
The *Figure 4.8* below shows the complete CO_2 emission from this category:

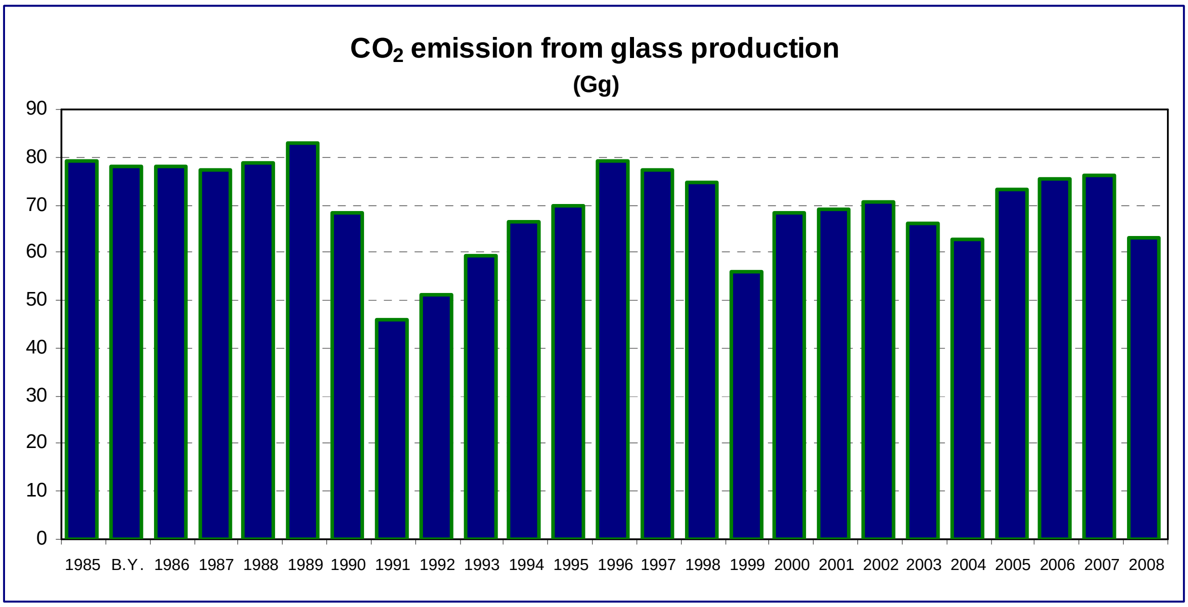


Figure 4.8. *CO_2 emission from Glass Production (1985-2008)*

The ERT noted that the time-series consistency between 1985-2005 and 2006 is not fully ensured by this calculation method, therefore recommended to make further efforts to improve time-series consistency. We have compared the CO_2 emission from ETS data with the emissions calculated with our country-specific factor and we have received the following results (*Table 4.5*):

Table 4.5. *CO_2 emission comparison, Gg*

	2006	2007	2008
CO_2 emission from ETS, Gg	75.275	76.147	62.980
Country-specific IEF-2005, Gg	68.050	71.781	73.593
Difference, Gg	7.225	4.366	-10.612

CO_2 emission from ETS was higher in 2006 and 2007 by 10.62% and 6.08%, respectively but lower in 2008 by 14.42%. The lower value was due to the new data logging methodology of the HCSO, i.e. estimations were made from salesmanship.

Recalculation

Last year there was no recalculation.

Planned improvements

None.

4.3.5. Bricks and ceramics (CRF sector 2.A.7.Other)

Technology

Emitted gas: CO_2
Key source: Level 1

Similarly to glass production, brick and ceramics production was put in the system also on

the basis of emission trade information. During manufacturing of 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 2008 was 311.96 Gg which is 0.5 % of the total CO_2 emission. The following table contains the data of production and emission:

Table 4.6. *Bricks and ceramics production and CO_2 emission in Industry sector (1985-2008)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bricks and ceramics. kt	6,339.6	6,275.8	4,509.4	3,500.9	3,978.9	4,207.6	4,784.3	4,217.0	4,222.7	4,437.6
CO_2 Gg	536.6	557.1	400.3	310.8	353.2	373.5	424.7	374.3	374.8	393.9
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Bricks and ceramics. kt	4,162.3	3,021.9	2,728.3	2,300.4	3,018.6	3,277.1	3,763.0	3,817.0	4,841.0	2,962.8
CO_2 Gg	369.5	268.2	242.2	204.2	267.9	290.9	334.0	360.5	357.6	312.0

4.4. 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.

Production of the chemical industry decreased further in 2008 compared to 2007. This is demonstrated well by the time series of the production data in the tables shown later and in the next figure.

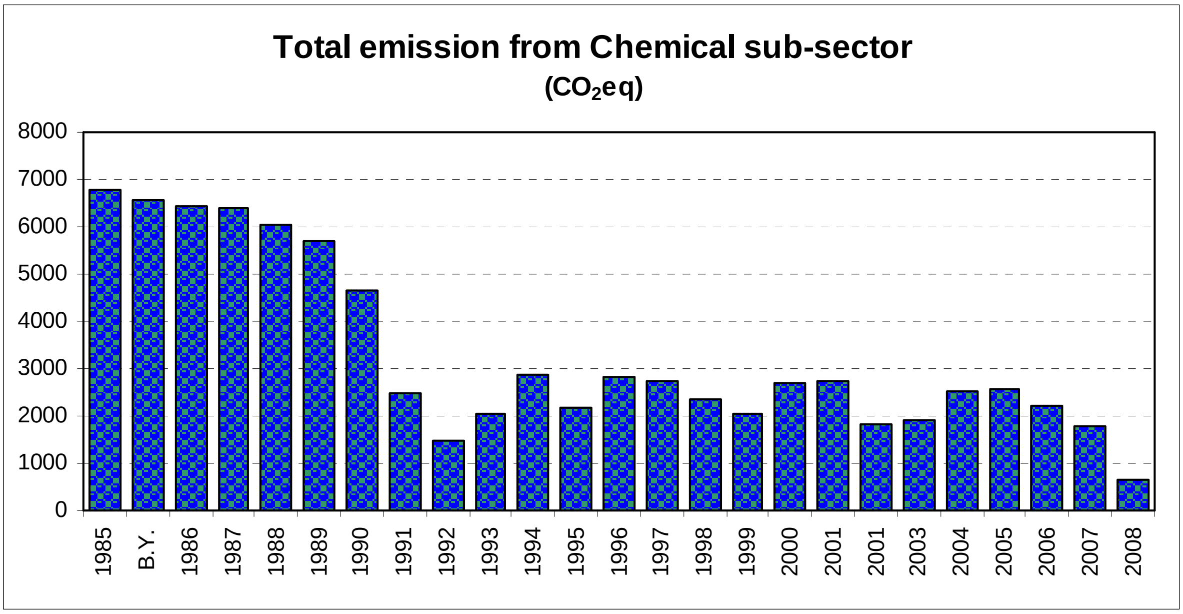


Figure 4.9. *Total emission from Chemical sub-sector (1985-2008)*

4.4.1. Ammonia Production (CRF sector 2.B.1)

Technology

Emitted gas: CO_2
Key source: Level 1, Trend 1

Traditional ammonia (NH_3) production uses natural gas whose carbon content 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. Out of the factories operating in 1985, one was abandoned in 1987, another in 1991, and a third in 1992. As regards 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 share of the latter in the production is about only 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 based on 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. According to the recommendation of ERT in 2007, we indicated the natural gas quantity instead of the previously used ammonia production in the CRF Report. Since the input of the natural gas quantity in cubic metres was not possible, it was given in tons.
The table below shows the amount of the used natural gas and the resulting emission data:

***Table 4.7**. Amount of natural gas used in the process, CO_2 emission and IEF tCO_2/tNH_3 in Chemical sub-sector (1985-2008)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Natural gas, kt	782.01	553.82	334.15	230.05	281.18	334.07	330.72	369.11	353.90	313.51
CO_2, Gg	1,995.97	1,415.53	838.06	562.28	687.24	816.50	808.32	902.16	864.98	766.27
IEF CO_2 (t/tNH_3)	2.1059	2.2412	2.3645	2.4829	2.3597	2.2299	2.1487	2.1360	2.0996	2.1872
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Natural gas, kt	279.67	361.59	326.22	232.75	231.52	297.96	336.40	316.36	345.52	262.32
CO_2, Gg	683.55	883.78	797.32	568.87	565.87	728.26	822.20	773.23	844.50	641.13
IEF CO_2 (t/tNH_3)	2.1546	2.0660	2.0217	1.9657	2.0082	1.9719	2.0690	2.0872	2.0692	2.1809

The *Table 4.7* above indicates that tCO_2/tNH_3 IEF value is around 1.97 to 2.48.

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

Last year there was no recalculation.

Planned improvements

None.

4.4.2. Nitric Acid Production (CRF sector 2.B.2)

Technology

Emitted gas: N_2O, (CO_2)
Key source: N_2O:Trend 1

Nitric acid (HNO_3) is produced by oxidizing ammonia. The process end gas contains N_2O and NO_X. 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 1988, another in 1991, and a third in 1995. Until 2006 two production lines were operated in the country – the older one was established in 1975 and used GIAP technology which consists of four units with four different factors. These four units represented the major part (about 80%) of the

production volume. Emissions from this process were measured from 2004. The other existing technology represented only 20% and had been operational since 1984 (combined acid factory producing diluted and concentrated nitric acid).
Implementation of a new and more advanced production technology was started in 2005, in the framework of a joint implementation project, and it was installed in September 2007. At the same time the old production lines were closed down. Now a state-of-the-art technology is used, therefore drastic emission reduction is reported in this inventory (see *Table 4.8*).

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 1988, 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 three other abandoned factories including the one which was abandoned in September 2007. For the combined factory, a value of 10 kg/t was used.
End of 2004, selective catalytic reduction was introduced in tail-gas treatment which led to emission reductions in the following years. This modernization means furthermore that the EFs before and after 2004 cannot be the same. The emission data of 2005 and 2006 are based on measurements. In the second half of 2005 a new measuring instrument was installed which might partly explain the difference between IEFs. Thus, the weighted average ranges between 10.01 and 14.51 kg/t in the time series, depending on the production volume. In 2007 EF decreased to 6.15 kg/t and to 0.0425 kg/t in 2008. The new factory applies the EnviNOx technology consequently a drastic reduction of emission has been reached. N_2O emission from nitric acid production was decreased by 99% between base year and 2008.
The amount of carbon dioxide generated during the reduction reaction is so low (a few tens of tons: max. 93.29 in the whole period; and 63.84 in 2003) that it has no detectable effect on the inventory as a whole. Nevertheless, following the recommendation of ERT, we supplemented the database with these emissions. Since 2004 process tail gas has been treated with ammonia, so CO_2 emissions are no longer an issue. From 2007, further information about consumption of natural gas data was received from the factory. This was used in a new plant as a tail gas reducing agent. Production data were obtained from the factories for each of the 24 years in the time series. These and the emission data are shown in the table below:

Table 4.8. *Nitric Acid production (kt) and N_2O emission in Chemical sub-sector (1985-2008)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Nitric Acid. kt	1013.09	732.35	377.47	210.55	310.34	460.11	310.28	453.83	433.53	354.44
N_2O. Gg	13.28	9.30	4.44	2.34	3.63	5.39	3.31	4.49	4.32	3.61
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Nitric Acid. kt	309.50	415.99	454.27	294.80	306.21	415.01	484.41	460.83	474.91	385.96
N_2O. Gg	3.16	4.18	4.54	2.92	3.08	4.12	5.59	4.61	2.92	0.02

EnviNOx technology

The EnviNOx process is usually located between the final tail gas heater and the tail gas turbine and contains two catalyst beds filled with iron zeolite catalysts operating at the same pressure and temperature and a device for addition NH_3 between the beds. In the first DeN_2O stage, the N_2O abatement is effected simply by the catalytic decomposition of N_2O into N_2 and O_2. Since NOx content of the tail gas promotes the decomposition of N_2O, the required DeNOx stage is arranged downstream of the DeN_2O stage.

In the second stage, NOx reduction is carried out using NH_3 as a reducing agent similar to natural gas.

Reactions in the DeN_2O:

$$2\,N_2O + 2NO \text{ ------->} 2\,N_2 + 2\,NO_2$$
$$2\,N_2O \text{ <------->} 2\,NO + O_2$$

$$2\,N_2O \text{ ------->} 2\,N_2 + O_2$$

Reactions in the DeNOx:

$$6\,NO_2 + 8\,NH_3 \text{ ------->} 7\,N_2 + 12\,H_2O$$
$$4\,NO + O_2 + 4\,NH_3 \text{ ------->} 4\,N_2 + 6\,H_2O$$

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.

QA/QC information

The data received directly from factories greatly improved the quality of data. This is of particular importance, because in the past only limited production data could be obtained from KSH (due to confidential technologies).

Recalculation

From 2007, information about consumption of natural gas data was received from the factory. This was used in a new plant as a tail gas reducing agent. The amount of released carbon dioxide are estimated from the carbon content which provided by IPCC Guidelines (1997)

Planned improvements

None.

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

Emitted gas: CH_4 , NMVOC

Key source: NO

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 carbon black process was a confidential technology because only one such process was operated in Hungary. Therefore, we could not calculate the related emissions. In 2005 we contacted the manufacturer and obtained production data and an emission factor characteristic of this 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 the emission factor was 0.0037 kgCH_4/t product which was in contradiction to the default value of 0.06 recommended by GPG in 2006.
Using production data obtained from KSH and default values recommended by IPCC, methane emission was calculated for the other two processes. In 2008, this value was only 0.727 Gg (0.01 %). Comparing to the data of the previous years (0.34-0.78 Gg), the effect of production decrease by ~8% in 2008 can be observed here as well.
Similarly, based on data obtained from the statistical office and using IPCC default values, also NMVOC emission was calculated for the other processes, for example pesticide production, ethylene, dichloroethylene, propylene. In 2008, these emissions amounted to 9.17 Gg.

4.5. Metal Production (CRF sector 2.C)

4.5.1. Iron and Steel Production (CRF sector 2.C.1)

Technology

Emitted gas: CO_2
Key source: Level 1

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:

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

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.

4.5.2. Ferroalloy Production (CRF sector 2.C.2)

Technology

Emitted gas: CO_2
Key source: NO

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.

4.5.3. Aluminium Production (CRF sector 2.C.3)

Technology

Emitted gases: CO_2, PFCs (CF_4, C_2F_6)
Key source: NO

During alumina 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. From the beginning of 2006 this technology is no longer in use.

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:

Table 4.9. *Amount of Aluminium Produced (t)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
Aluminium, t	73.75	75.19	75.16	62.88	26.82	27.88	29.65	31.91	33.47	33.71
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Aluminium, t	33.64	33.85	34.59	35.29	35.04	34.35	31.78	NO	NO	NO

Measured emission data were 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:

Table 4.10. *CF_4 emission in Aluminium Production 2.C.3 sub-sector (1985-2008)*

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
CF_4, Gg	36.18	36.50	31.50	18.17	19.64	21.42	22.48	21.48	21.41	23.05
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
CF_4, Gg	23.60	28.40	26.75	27.19	25.38	26.96	28.01	NO	NO	NO

For each year, emissions were calculated for individual factories and the sum of these is used as annual total. You can found detailed 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, which were 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 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 operated an accredited quality assurance system. We have seen very well kept production records. The necessary data were given to us 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.

4.6. Other Production (CRF sector 2.D)

In this sector only indirect gases from sub-sectors Pulp and Paper and Food and Drink are reported.

4.7. Production of Halocarbons and SF_6 (CRF sector 2.E)

Halocarbons and SF_6 are not produced in Hungary.

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

4.8.1. Technology

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

HFCs (partially fluorinated hydrocarbons) are used in household and commercial cooling equipments (CRF 2.F.1.), during production of foams used in construction/insulation industry (CRF 2.F.2.), medical and technical sprays (as propellant gas) (CRF 2.F.4.).
PFCs (fully fluorinated hydrocarbons) are used as solvents or as an ingredient of cooling mixes, 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. It is further used as 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 colored metal foundries.

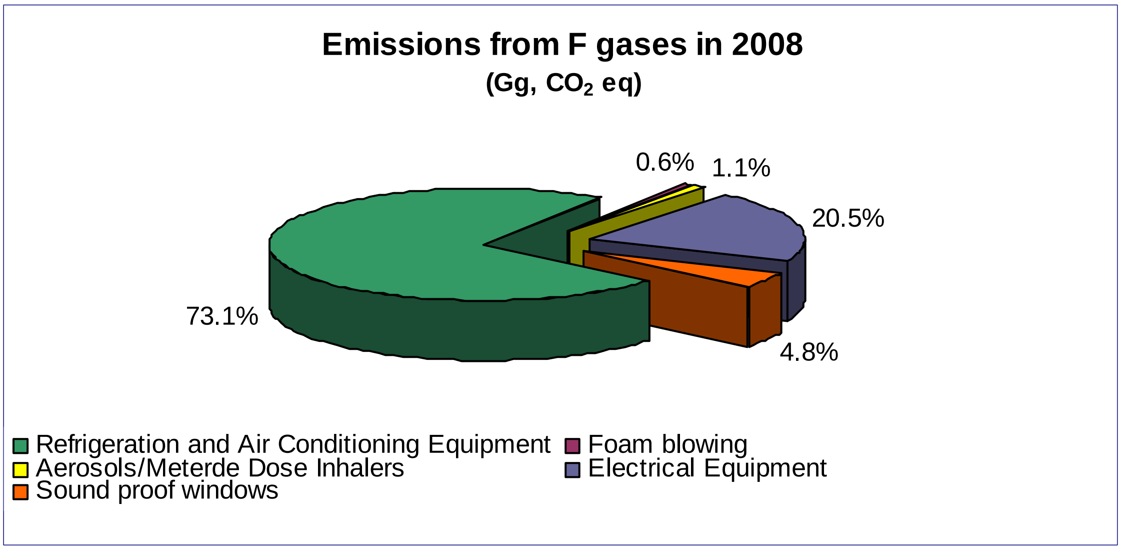


***Figure 4.10**. Emission from sub-sectors of F gases in 2008, Gg CO_2eq*

4.8.2. Methodology

In cooling industry, the imported HFCs are either filled into new equipments or are used to refill the cooling medium of installed equipments. It is assumed that the quantities previously released into the atmosphere are replenished and these amounts 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 emissions were calculated on the basis of a preliminary study prepared by László Gáspár, Institute of Environmental Management in 1998, later the calculations were improved.

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. HFC-134a is also used in foam material production, and so was HFC-152a in 2006 and 2007.

In calculating the emission of HFCs used in foam blowing for the year 2005, we changed to the method and the specific factors recommended by GPG. The data of 2003 were recalculated with the help of this method. The HFC-365mfc values were taken out of the database.

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. As regards 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. When a company could not provide data for a given year, this was determined by estimation.

2.F.1 Refrigeration and Air Conditioning Equipment

Emitted gases: HFC-125, HFC-32, HFC-143a, HFC-134a, HFC-152a, HFC-23, C_3F_8

Emission data, export-import data, refilled amount of domestic refrigerators were received directly from the manufacturer from 1992. Initially, the manufacturer used HFC-134a as a chemical charge for the replacement of R12. R600 has been applied from 1994 and its use has been significantly increased. Nowadays, this chemical is used predominantly.

Fugitive assembly emissions do not occur when the equipments are filled because the system of filling is a closed system.

In case of commercial and industrial equipments, distributors or trading companies were contacted to get information on the quantities used for filling new refrigerators and for refilling existing ones. For certain operators, the filling/refilling ratio was determined by estimation taking into account their activities This refilled amount was taken as emission, i.e. in such cases emissions were calculated without using emission factors.

2.F.2 Foam Blowing

Emitted gases: HFC 134a, HFC-152a, HFC-227ea

HFCs are being used in foam applications such as insulating, cushioning, packaging, the automotive industry, furniture manufacturers, medical appliance and cosmetic industry. Export and import data were obtained from the factories from 2003. The mixture (HFC 227ea/365mfc) is used for the production of both soft and hard foam. HFC-134a is also used in foam material production, and HFC-152a used in 2006 and 2007. The IPCC Guidelines suggest calculating emissions from open-cell foam separately from closed-cell foam.

Open-Cell Foam:

Since HFCs used for open cell foam blowing are released immediately, all of the emissions will occur in the country of manufacture. Emissions are calculated according to the following equation:

Emissions from Open-Cell Foam = Total Annual HFCs Used in Manufacturing Open-Cell Foam

Closed-Cell Foam:

Emissions from Closed-Cell foam occur from the following:

1. First year losses from manufacture, these emissions occur where the product is manufactured.
2. Annual losses (in situ losses from foam use). Closed-cell foam will lose a fraction of their initial charge each year until decommissioning. Since we had no information about decommissioning amount, it was assumed that all chemical not emitted in manufacturing is emitted over the lifetime of the foam.

The applied equation is the following:

Emissions from Closed-cell Foam **=** [(Total HFCs Used in Manufacturing New Closed-cell Foam in year t) • (first-year Loss Emission Factor)] + [(Original HFC Charge Blown into Closed-cell Foam Manufacturing between year t and year t – n) • (Annual Loss Emission Factor)]

The used default assumptions for our calculations are shown in *Table 4.11*.:

***Table 4.11**. Default emission factor for HFCs from Closed-Cell foam*

Default emission factor for HFCs from Closed-Cell foam	
Emission Factor	**Default Values**
Product Lifetime	n = 20 years
First Year Losses	10% of the original HFC charge/year
Annual Losses	4.5% of the original HFC charge/year

The equation above was applied to each chemical individually. Total CO_2eq emissions are equal to the sum of CO_2eq emissions of each combination of all chemical types. To implement this approach it was necessary to collect current and historical data on annual chemical sales to the foam industry for the period.

2.F.4 Aerosols and Metered Dose Inhalers

Emitted gases: HFC 134a, HFC-152a.

Most aerosol packages contain mainly hydrocarbons (HC) as propellants, but in a small fraction also HFCs are used, especially HFC-134a in industrial applications, and household and medical products.
Emissions from aerosols occur shortly after production, all the initial charge escapes within the first year. Therefore, to estimate emissions, it is necessary to know the total amount of

aerosol initially charged in product containers prior to sale. It was assumed that all chemical substances were emitted in the operating systems.
Metered dose inhalers were produced from 1999. Small fraction of the production was used within Hungary, most of them were exported. Technical sprays, like spray duster and freezing spray were manufactured and used from 2000. Information about HFCs was obtained directly from producers or distributors.

2.F.8 Electrical Equipment

SF_6 is also imported and is mainly used as an insulation gas in electrical switchboards. Consumption and some emission data were obtained directly from the users. However, only one company could provide data for the initial years therefore aggregated activity data were determined by estimation up to 1997, 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.

2.F.9 Other applications

SF_6 is used in a variety of additional applications including its usage as an insulating medium in sound proof windows. Information of traded gases were obtained from distributors, the calculation formula is based on the basic method (Tier1). Due to lack of accurate information, data for 1992-96 are estimated values, but according to the distributor, these values should be similar to that of 2002.

Potential emission= Import-Export

Cross cutting information

HFC-365mfc are F-gases that are not regulated under the Convention; this is why emissions of these gases are not included in national totals, but reported in CRF Table 9(b) as additional GHG.

4.8.3. Uncertainties and time-series consistency

Trading companies, mainly involved in commercial refrigerators, gave estimates on the proportion of the imported HFCs used for refilling that were associated with a high level of uncertainty and the error may be as much as 10 to 20 per cent. 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.

4.8.4. QA/QC information

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

4.8.5. Recalculation

The ERT recommended several changes for Hungary, and the following were done:

- Potential emissions of HFCs aerosols/metered dose are reported instead of NE.
- Activity data from the year 1999 has been updated since the last submission. This recalculation resulted in an increase of emissions, as shown in *Figure 4.11*. :

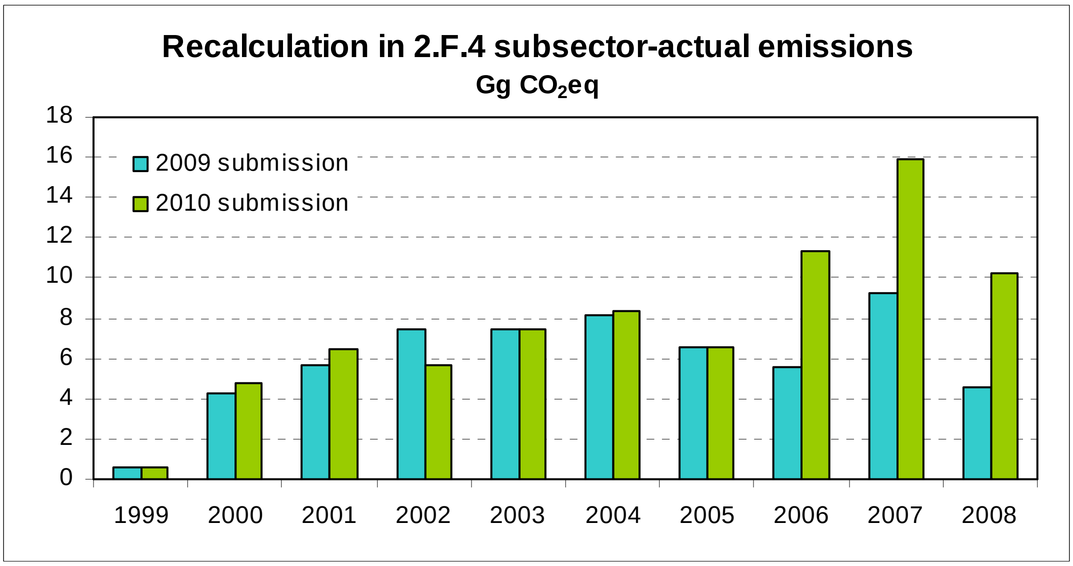


***Figure 4.11**. Changes in 2.F.4 subsector*

- In case of HFC-134a, activity data in domestic refrigeration has been included also for manufacturing.
- To use appropriate notation keys, NO instead of NE or IE, for example in commercial refrigeration C_3F_8, domestic refrigeration, fire extinguishers
- A copying error of SF_6 use in 2.F.8 Electrical Equipment was corrected for 2007.
- Potential emissions of HFCs from foam blowing were reported instead of NE.

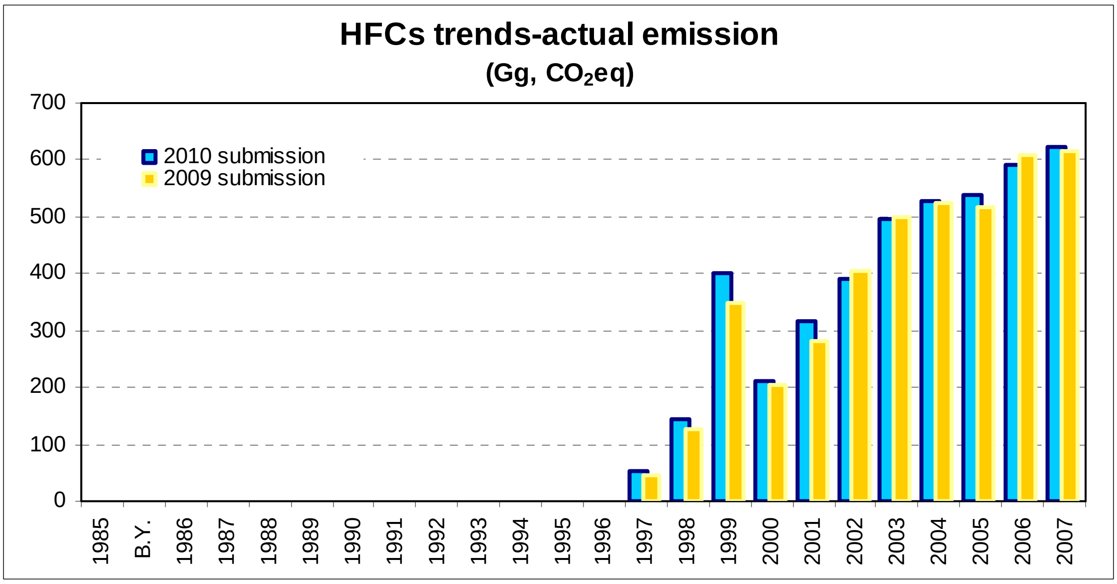


***Figure 4.12.** HFCs trends (1997-2008)*

4.8.6. Planned improvements

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

4.9. Other (CRF sector 2.G)

Technology

Emitted gases: CO_2
Key source:

Methodology

This category was created for calculating carbon dioxide emissions from fuels used as feedstock or other non-energy purposes. CO_2 emissions arise from oxidization during use. Methane emissions are expected to be minor or not to occur at all.

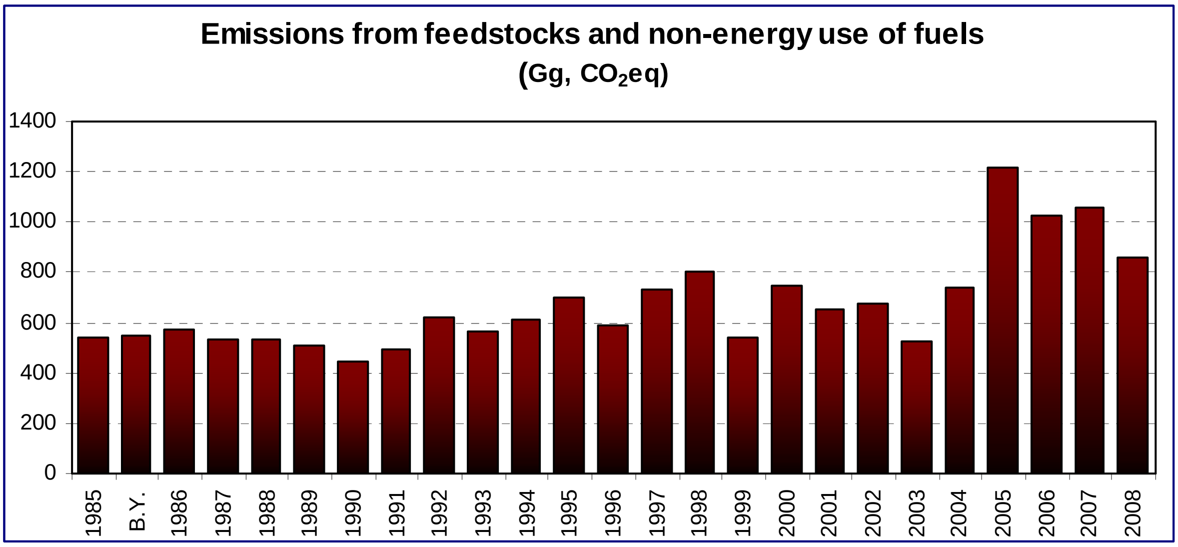


Figure 4.13. *Emission from feedstock and non-energy use of fuels Gg, CO_2 eq*

The use of fossil fuels as feedstock or for other non-energy purposes is reported in an aggregated manner by Energy Statistics under "Non-Energy Use" for each individual fuel. It is an aggregated category because the real consumers of these fuels are unknown. These kinds of oil products are widely used. Just a few examples: paraffin waxes are used for candles, corrugated boxes, paper coating, board sizing, adhesives, food production, packaging; lubricants are consumed in transportation and industry; white spirit, kerosene, some aromatics are applied as solvents e.g. for surface coating (paint) and dry cleaning.
Whenever CO_2 emissions resulting from non-energy fuel use are allocated to another category of the Industrial Processes Sector, those emissions are subtracted from the total non-energy emissions to avoid double counting. For example natural gas used as feedstock in ammonia and nitric acid production, ethylene and carbon black manufacturing is not reported here.
The amount of released carbon dioxide are estimated from the carbon content of fuels and fraction of carbon not stored which are based on figures provided by IPCC Guidelines (1997). Bitumen or asphalt for road paving and roofing is taken into account in the appropriate subsector in industrial processes.

Recalculation

It is a new category.

Planned improvements

This category contains a number of unknown consumers of these fuels. In order to avoid

double counting, further analysis is needed.

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

5.1. Overview of the sector

Emitted gases: N_2O, CO_2, NMVOC
Key sources: N_2O Level 1,2

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

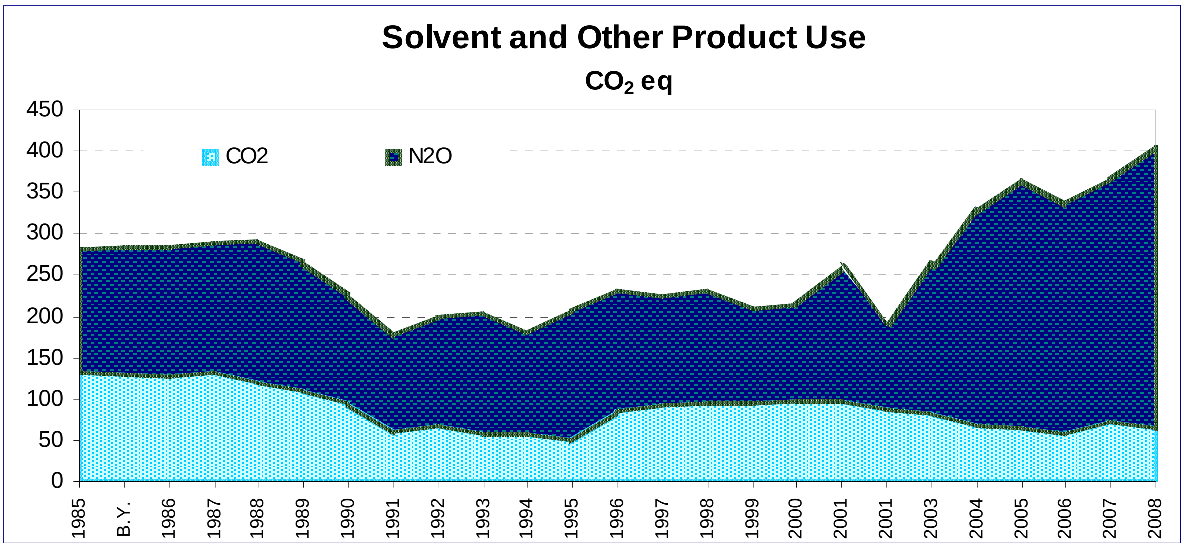


Figure 5.1. *CO_2 and N_2O emissions in Solvent and Other Product Use sector (1985-2008)*

In 2008 this category had a contribution of 0.55% (excluding LULUCF) to total greenhouse gas emissions (406.30 Gg CO_2 equivalents). There has been an increase of 42.79% from base year to 2008 and a rise of 10.97% between 2007 and 2008.

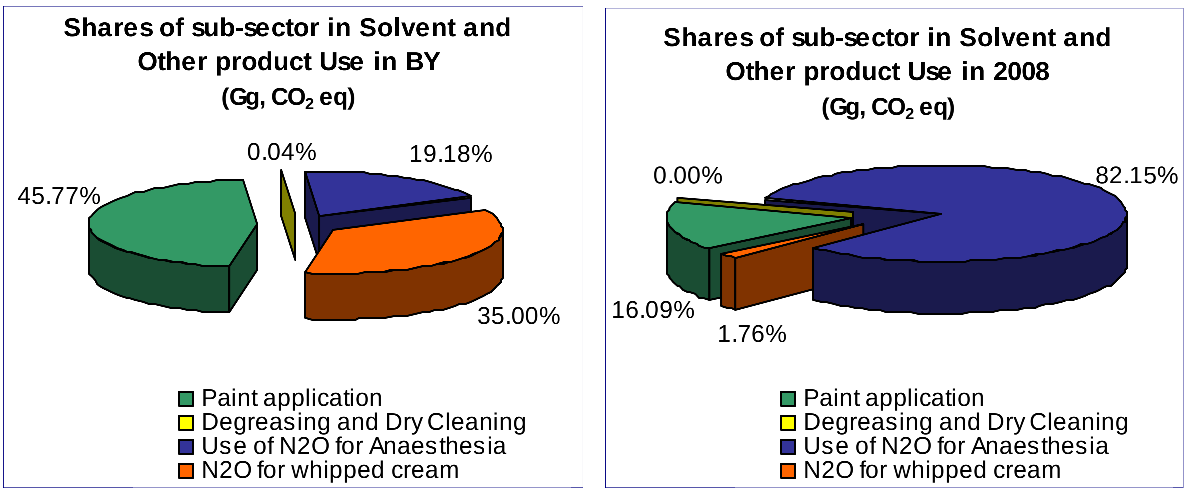


Figure 5.2. *Shares of sub-sectors in Solvent sector, in base year and 2008 (Gg CO_2eq)*

In the base year, the paint application sub-sector accounted for 45.77% of total GHG emissions from solvents, followed by emission from whipped cream sub-sector 35.0%, use of N_2O for anaesthesia sub-sector 19.18% and degreasing and dry cleaning 0.04%. In 2008, use of N_2O for anaesthesia sub-sector accounted for 82.15%, followed by paint application 16.09%. Less than 2% arose from whipped cream sub-sector and only a slight amount from degreasing and dry cleaning sub-sector (*Figure 5.2*).

5.2. Solvent Use (CRF Sector 3.A, 3.B)

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. In 1996, KSH altered the type of data collection, and this is the cause of increase in that year in the diagram above. Compositions and solvent contents were discussed 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 emission factors show in the next table (t emission/t paint):

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

	BY	1990	1991	1992	1993	1994	1995	1996	1997	1998
IEF NMVOC, t/t	0.318	0.267	0.278	0.290	0.255	0.241	0.224	0.381	0.361	0.283
IEF CO_2 t/t	0.932	0.779	0.810	0.845	0.737	0.693	0.641	1.115	1.051	0.806
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
IEF NMVOC, t/t	0.277	0.263	0.252	0.224	0.204	0.184	0.219	0.226	0.236	0.204
IEF CO_2 t/t	0.790	0.744	0.709	0.624	0.564	0.502	0.616	0.637	0.668	0.568

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.D)

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):

Table 5.2. *N_2O emission (1985-2008, t)*

N_2O (t)	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Anaesthesia	176.04	215.35	214.26	261.37	308.84	252.00	353.98	333.03	298.95	328.16
Cartridge	321.29	206.65	162.74	164.63	167.16	137.00	145.02	136.97	131.05	112.84
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Anaesthesia	275.08	304.45	459.31	275.22	533.02	789.69	931.90	864.45	926.77	1,076.66
Cartridge	95.92	70.55	60.69	55.78	44.98	37.81	38.60	29.59	23.48	23.10

The cartridge refilling loss is high (approx. 30 %) and this 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

Activity data from the year 1985 has been updated since the last submission. This recalculation resulted in a decrease of emissions.

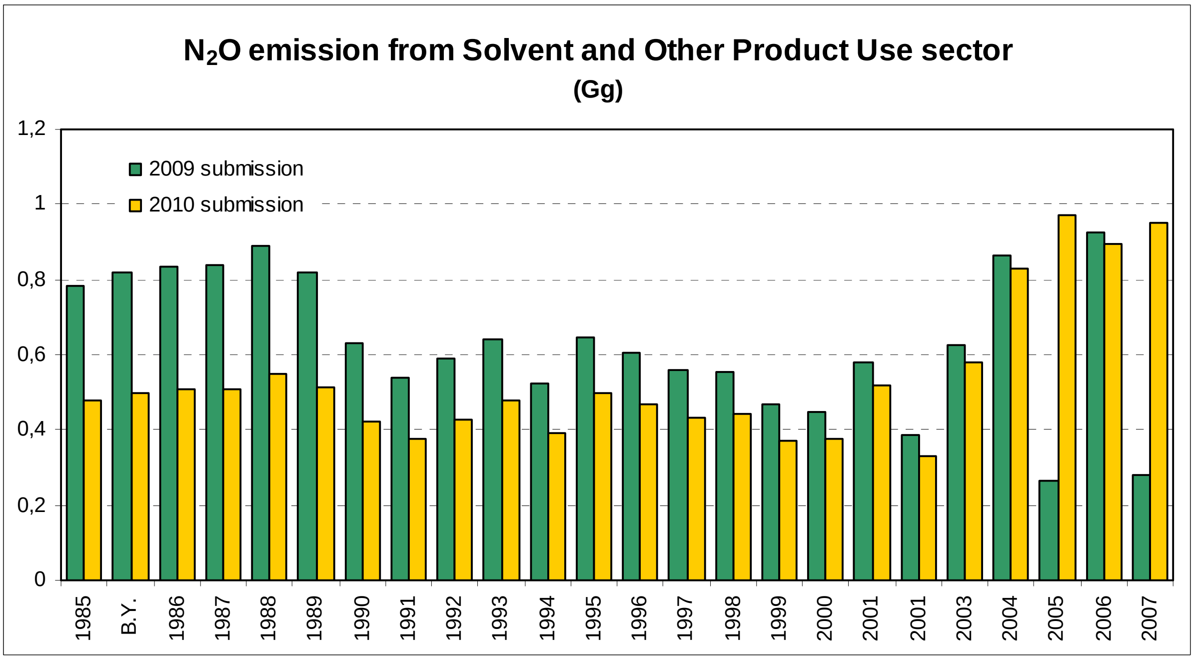


***Figure 5.3**. Changes in N_2O emissions (Gg)*

5.3.6. Planned improvements

None.

6. AGRICULTURE (CRF sector 4.)

6.1. Overview of the sector

Between 1985 and 2008 agriculture production contributed to the greenhouse gas emission at national level through the following processes:

- Animal breeding: enteric fermentation by livestock, manure management and use
- Rice cultivation
- Agricultural soils
- Field burning of agricultural residues

Energy consumption of agriculture activities (heat production agricultural vehicles and machinery) was taken into account in the Energy chapter (chapter 3, CRF sector 1).

The main characteristics of the Hungarian agricultural sector were the following:
Hungary has favourable national endowments to agricultural production (e.g. soil quality, climate), agriculture is traditionally export-oriented and had additional export even in terms of the EU relation.
As the result of the political and economic processes after the change of regime 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 almost about 50%.
After Hungary joined the European Union (1 May 2004) the field of agriculture faced serious challenge in terms of the establishment of harmonization with the Union legal regime, the establishment of the institutional system necessary to operation, the education of experts and the preparation of the producers.
The Hungarian agriculture sector was disadvantageously affected by the fact that the new Member States receive gradually the 100% of the direct Union payments, after a 10-year transition period, starting from 25%. Top-up payment may be provided up to 30% as a complement.
As the result of the accession the Hungarian agriculture got under conditions that were significantly different from the former environment. Hungary had to compete with such member countries on the single internal market that have been the developers and the beneficiaries of the competition for years or even decades, and the degree of the subsidies was also rather different. After combating the initial difficulties (in compliance with the follow-up financing requirements of the agriculture finance system had to be converted from the short-term type into medium and long-term loans as well as the introduction of direct payments required the operation of a brand new system), the Union aid scheme has been operating relatively well since the end of 2005. The total opening of the markets towards both directions resulted in the worsening of the agricultural trade balance in the first two years. The Hungarian agriculture sector were able to maintain its positive trade balance after the accession but – collaterally with the increasing export – the proportion of the import showed higher increase. On the single internal market the competition problems of the pig and poultry sector sharply emerged, and in the case of the vegetable-fruit sector the beneficial impacts emerged slowly than it was expected. Between 2004 and 2006 the proportion of the crop and animal production shifted in favor of crop production within the gross production. The concentrated nature of processing industry and mainly of retail supply and the dominance of foreign capital had disadvantageous impacts on the position of producers on the domestic market. The compliance with the animal welfare and environmental requirements in animal production required (and still requires) enormous efforts. This required and still requires significant additional investments. Finally, the Hungarian

agriculture has accommodated to the conditions of the Common Agriculture Policy, competitiveness improved, the export revenues became more and more significant due to the excellent agricultural potency of the country and trade balance improved, too. The positive balance of the agriculture trade was HUF 265 billion in 2006, HUF 402 billion in 2007 and HUF 482 billion in 2008. In terms of euro the balance of 2008 increased by 14.3% compared to the EUR 1,675.2 million of 2007, and exceeded EUR 1,915 million. In 2008 our export reached about EUR 5.7 billion that was more than the double of the level in 2000. The traditionally positive agricultural trade balance has been positively influencing the country's trade balance for decades. The structure of export relations has gradually shifted: the share of the new member states and of third countries is increasing against of the old member states (traditional EU).
In 2008 the share of the Hungarian agriculture sector was 4.0% in the GDP, 25.0% in the consumption, 7.9% in the export, 5.0% in the investments, 4.6% in the employment; the trade balance was HUF 482.0 billion (forecast data, HCSO, 2009). If – beyond the agricultural raw material production – the performance of food industry, food trade and agricultural services as well as the field of sectoral management and administration and education, research and agriculture diplomacy are taken into account, the share of the so-called agri-business was 12-13% in the GDP in Hungary in 2008, while raw material production itself covered only 4% of the GDP.

The share of the agriculture sector shows decreasing tendency both in the GDP and in the consumption. The degree of reduction within the consumption is less than in the case of GDP production since the share decrease of food consumption occurred within an increasing total consumption. In Hungary in 1995 the share of food represented 32.4% in the basket of food; it has never reached 30% since 2000 and was about 25% in 2007 and 2008.
The share of agriculture in national investments was 6.1% in 2003; it decreased to 4.2% in 2006 and to 3.7% in 2007. When judging investments it is decisive that significant investments (mainly machinery) were realized in the years after the accession in the framework of the measures of the SAPARD (Special Accession Programme for Agriculture and Rural Development) and the AVOP (Agriculture and Rural Development Operational Programme), and after the decline in 2006 the new investment programmes that are connected to the New Hungary Rural Development Programme (ÚMVP) to be implemented between 2007 and 2013 brought the significant boost of investments.
According to the data of employment survey the number of employees in the agriculture sector has further decreased between 2006 and 2008, and its share hardly reaches 4.6% within the national economy. The role of the sector is much more significant in employment than it is indicated by the statistics since the vast majority (almost 80%) of labour input used in agriculture is the non-paid family workforce in Hungary. However, the degree of employment calculated on the basis of the hours worked is about half a million people in the agriculture sector.
The Hungarian agricultural sector was able to maintain its positive trade balance even after the EU accession. In 2008 the magnitude of the export reached about EUR 5.7 billion that was more than the double of the level in 2000. The positive balance of the agriculture trade was HUF 265 billion in 2006, HUF 402 billion in 2007 and HUF 482 billion in 2008. The traditionally positive agricultural trade balance has been positively influencing the country's trade balance for decades.
There were 387,678 enterprises operating in the field of agriculture, forest management and fishery in 2008. The number of the incorporated companies increased by about 7% in the last two years. The number of public limited companies stagnated, the number of co-operatives is decreasing year by year. The number of individual farms is also decreasing, only 600,000 ones were operating in 2008. The decrease accelerated mainly in the field of farms with animal breeding or gardening profile in the past years.
In 2007 76.5% of the business units used land of agricultural purposes, their average agricultural area was 386 hectares. The individual farms using land of agricultural purposes (91.5%) cultivated an agricultural area of 3.6 hectares on average. The average area of

business units has decreased by 3%, the average area of individual farms has increased by 13% since 2005. In the case of business units the farm size above 300 hectares was prevailing. Farms of the size between 10 and 300 hectares (6% of the farms) possessed 73% of the agricultural area of individual farms. In 2007 29% of business units and 55% of individual farms pursued animal keeping.
As regards land use, out of the area of the country (93,303 km2) 83.5% is productive land area (48.4% arable land, 3.0% kitchen garden, orchard and vineyard, 10.9% meadow and pasture, 20.3% forest, 1.0% reed and fishpond), 16.5% is uncultivated land. Out of the area of the country 40.7% is managed by agricultural enterprises, 30.3% by private farms, 29.0% is unidentifiable (HCSO 2009).

6.2.1. Emission trends

In 2008, 12.6% of the GHG emissions expressed in CO_2 equivalents of the Hungarian economy can be linked to the agricultural sector.
The trend between 1985 and 2008 is summarized in Figure 6.1 (all emissions in CO_2 equivalents). As a result of the production decrease between 1990 and 1995, greenhouse gas emission from agriculture activities reduced significantly. In the period between 1996 and 2008, the level of production was essentially stagnating or slightly decreasing, particularly in animal production. The greenhouse gas emission of agricultural activities was changed essentially in accordance with the activity data: it slightly increased between 1995 and 2000 and stagnated between 2000 and 2008.
In 2008, the greenhouse gas emission from the agricultural sector was 48% of the average of 1985-1987. Figure 6.2 shows the trend between 1985 and 2008.
The constant decrease in methane emissions (Figure 6.3) in the period is the result of the constant reduction of the number of animals. Nitrous oxide emissions show similar trends (Figure 6.4) until 1995, and there were a slight increase between 1996 and 2008. The main reason is the increase in fertilizer use. (Nevertheless, fertilizer use of the Hungarian agriculture sector is still only slightly higher than half of the amount between 1980 and 1985.)

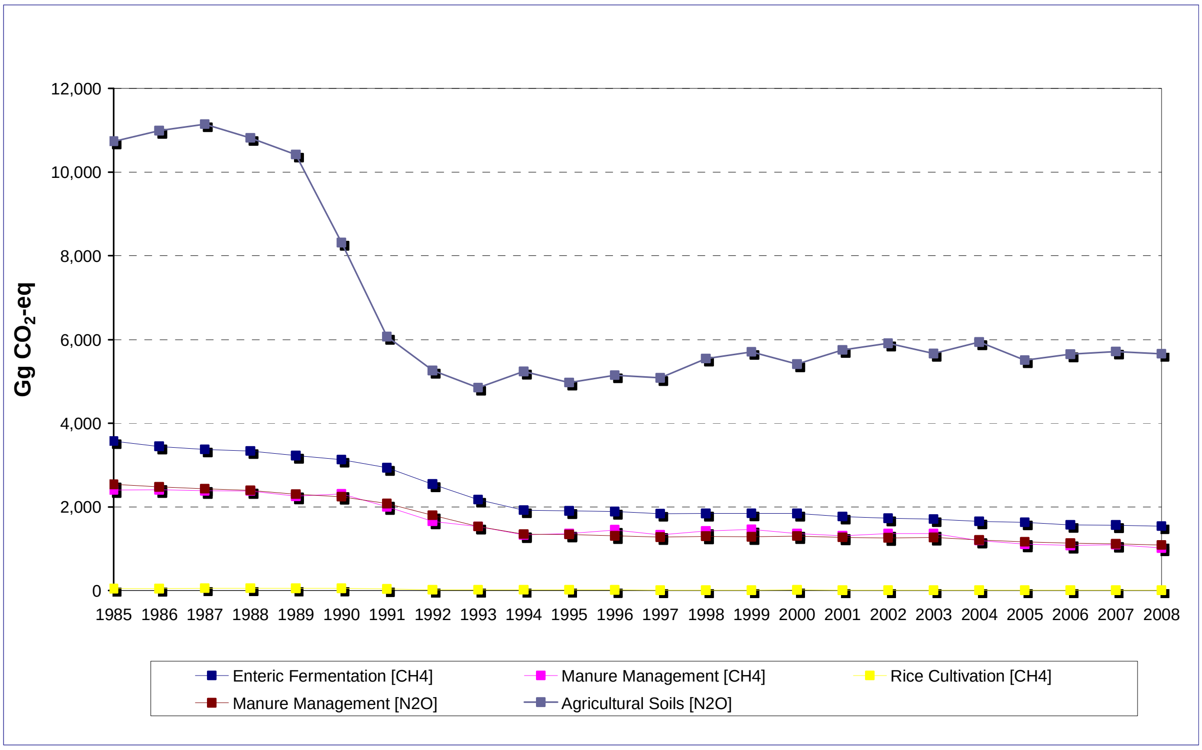


Figure 6.1. GHG emissions from Agriculture in CO_2-eq

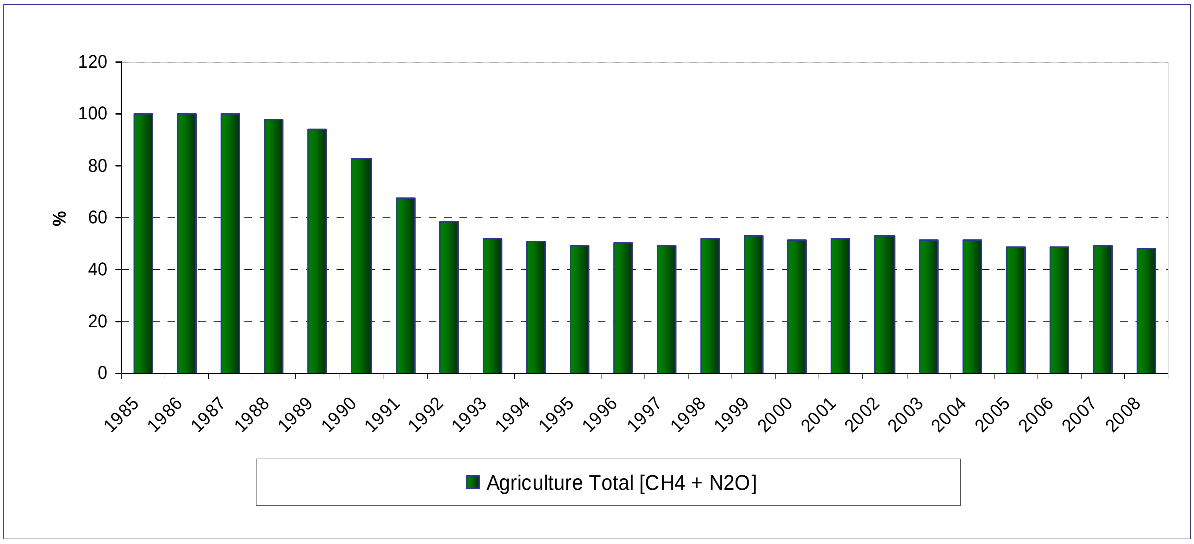


Figure 6.2. *GHG emissions from Agriculture in % of base years*

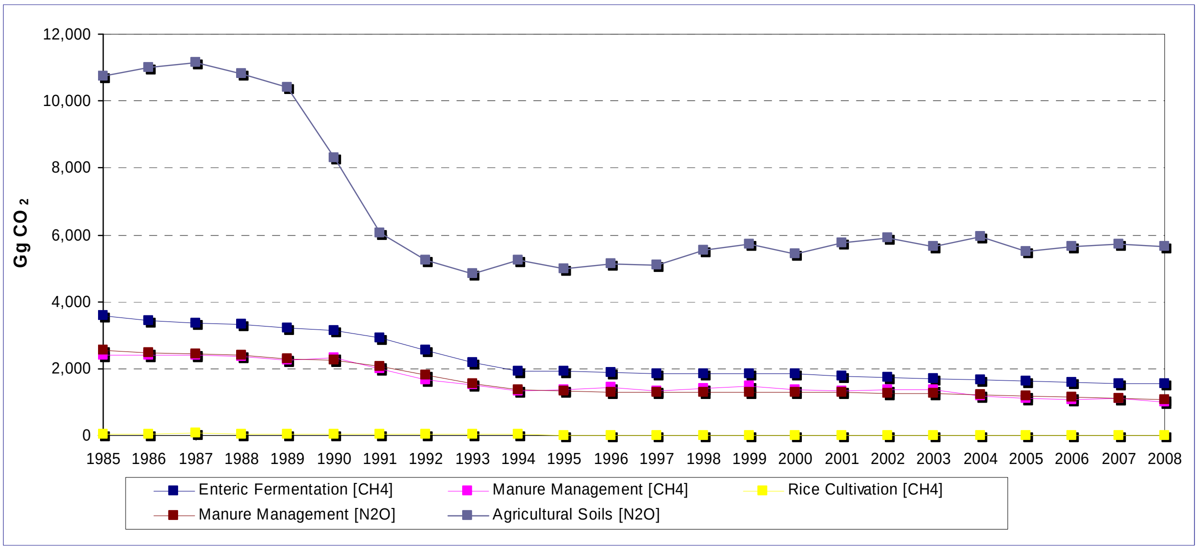


Figure 6.3. *CH_4 emissions from Agriculture*

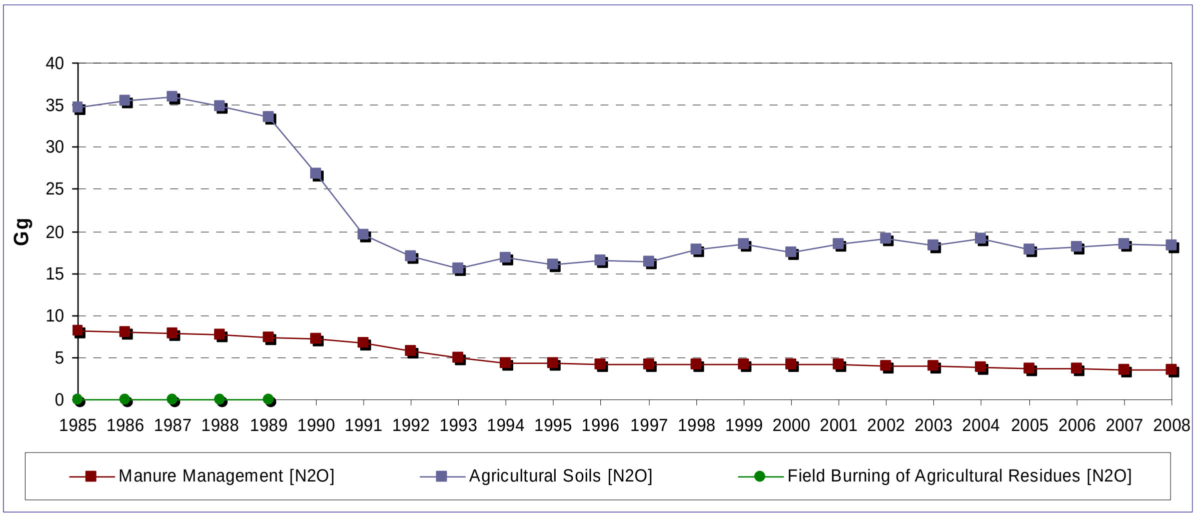


Figure 6.4. *N_2O emissions from Agriculture*

6.2.2. Key Categories

Key category analysis is presented in Chapter 1.5, Table 1.1 contains the key categories of agriculture sector.

6.2.3. Methodological issues

In accordance with the recommendation of the Centralized Review 2008 IPCC Tier 2 method was applied in the following categories: 4A Enteric Fermentation Dairy Cattle, 4A Enteric Fermentation Non-Dairy Cattle, 4B Manure Management (CH_4) by all livestock categories, except Rabbits. In other categories IPCC Tier 1 method was applied. Country-specific factors were used where there is enough information, otherwise the IPCC default factors were applied. See the individual categories for further details.

6.2.4. Uncertainties and time-series consistency

At the moment there are few country-specific data in the field of uncertainty assessment, so GPG2000 Tier 1 method was applied for uncertainty calculations.
The uncertainty of the activity data was calculated on the basis of the available data of the HCSO and of expert judgement; the uncertainty of the emission factors was calculated on the basis of the GPG 2000 recommendations. Uncertainties were combined in accordance with GPG 2000 Equation 6.3 and Equation 6.4, and Table 6.1 contains the results.
Out of the key categories the uncertainty of the Direct Soil Emissions and the Indirect Soil Emissions categories have the highest value. These high values derive from the uncertainty of the activity data (to a smaller extent) and of the emission factors (to a greater extent).

Table 6.1. ***Uncertainties of Activity Data, Emission Factors and Emissions***

4 Agriculture	GHG	Combined uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%	%	%
4A Enteric Fermentation	CH_4	2.6-10.0	50	28.07
4B Manure Management	CH_4	0.2-22.4	50	43.19
4B Manure Management	N_2O	51.0-54.8	150	67.70
4C Rice Cultivation	CH_4	201.6	80	216.91
4.D.1 Direct Soil Emissions	N_2O	34.5-62.3	250	159.63
4.D.2 Pasture, Range and Paddock Manure	N_2O	40.9	150	155.48
4.D.3 Indirect Emissions	N_2O	61.7-79.4	50	68.58
4.F Field Burning of Agricultural Residues	CH_4	not estimated	not estimated	not estimated
4.F Field Burning of Agricultural Residues	N_2O	not estimated	not estimated	not estimated

6.2.5. Quality Assurance and Quality Control

The agricultural greenhouse gas inventory is compiled by an external expert. The activity base data used in the calculations are derived from the official database of the HCSO. The documentation of the QA/QC methods used by the HCSO can be found in the referred databases (HCSO 1985-1989 and 1997-2005; 1990-1996; 2000a; 2000b; 2001; 2007a; 2007b; 2008a; 2008b; 2008c, 2009a, 2009b). The country-specific and the most appropriate default factors of the applied Tier 1 and Tier 2 methodologies were selected on the basis of expert consultations, the aspects and the justification of selection were documented. Calculation files contain checking data series. Data identity between data sources,

calculation files and the CRF is controlled by a member of the GHG division.
In the course of the compilation of the inventory the calculation documentation (data, calculation files, CRF) done by the external expert on the basis of the general QC measures summarized in Table 8.1 GPG2000 as well as of the QA/QC measures listed at the individual source categories is checked by a member of the GHG division.
The documentation is archived by the Hungarian Meteorological Service Greenhouse Gas Division and the Institute for Animal Breeding and Nutrition independently from each other. External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

6.2.6. Recalculations

Recalculation occurred in the following categories and years:

- 4.A Enteric Fermentation, CH_4 Emissions, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.B Manure Management, CH_4 and N_2O Emissions, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.D.1.2 Agricultural Soils, Direct N_2O-Emissions, Animal Manure Applied to Soils, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1985-2007 (values for ResO/CropO corrected)
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1986-2007 (Correction of calculation error in relation of rice and other cereals)
- 4.D.2 Agricultural Soils, Direct N_2O-Emissions, Pasture, Range and Paddock Manure, 2000-2007 (new activity data for Asses and Mules)
- 4.D.3.1 Agricultural Soils, Indirect N_2O-Emissions, Atmospheric Deposition, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.D.3.2 Agricultural Soils, Indirect N_2O-Emissions, Nitrogen Leaching and Run-off, 2000-2007 (new activity data for Asses and Mules and Poultry)

6.2.7. Planned improvements

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 (methane, nitrous oxide) inventory” is in progress. In accordance with the recommendation of the Centralized Review currently the following problems are to be solved:

- Enteric Fermentation: Improvement of the calculation method of CH_4 emission from enteric fermentation in the case of Dairy Cattle and Non-Dairy Cattle categories. Introduction of Tier 2 method for the other livestock categories.
- Manure Management, CH_4: Improvement of the calculation method of CH_4 emission from manure management for all livestock categories.
- Manure Management and Agricultural Soils, N_2O: Introduction of Tier 2 method as well as elaboration of country-specific values for all livestock categories regarding N-excretion.
- Improvement of uncertainty assessment.

6.2. Enteric fermentation (CRF sector 4.A.)

6.2.1. Source Category Description

Emitted gas: CH_4
Key source: Level 1, Trend 1

Enteric fermentation in animals is considered as significant source of CH_4 all over the world. The most important process of generation is anaerobic cellulose degradation in the rumen of ruminants. Some CH_4 is generated in the colon of horses and rabbits, and in the caecum of poultry. In Hungary the leading CH_4 emitters are cattle and sheep, 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. In 2008 60% of the entire CH_4 emissions from agriculture derived from this source category.

6.2.2. Methodological issues

6.2.2.1 Calculation method

Emissions from enteric fermentation of livestock were calculated by using the Tier 1 method of GPG 2000, except for the Dairy Cattle and the Non-Dairy Cattle categories, where country-specific emission factors were calculated on the basis of Tier 2 method of GPG 2000.

The elaboration of the parameters necessary to the Tier 2 calculations occurred as follows:

Dairy Cattle - The average body mass was determined on the basis of expert judgement. The experts skilled in the theory and practice of dairy production from the Research Institute for Animal Breeding and Nutrition were involved in the consultation (Dr József VÁRHEGYI, Ph. D., Head of Department Ruminant Nutrition, Dr Ildikó Ms VÁRHEGYI, Ph. D., Head of Department Feed Analysis and Evaluation, Dr István GYÖRKÖS, Ph. D., habil., Head of Department Cattle Breeding).
In Hungary the Dairy Cattle population consisted mainly of Holstein-Friesian and Holstein-Friesian Cross-bred in 1985 and still does. Therefore we estimated the average mass as 600 kg that was characteristic of the breed in 1985. In the case of this breed the selection for milk yield resulted in growth of body size and body mass. For 2005 the average body mass was estimated as 650 kg. The average body mass was calculated with the help of interpolation for the years between. For the year of 2006-2008 minimal increase (1 kg per year) was calculated.
The GPG2000 Table 4.8 provides Y_m value between 0.055 and 0.065 (0.060 ± 0.005), depending on the composition (concentrate %), quality and digestibility of the feed ration. In Hungary the dairy cattle population generally receives good quality TMR fodder, depending on the dairy production level, along with relatively high fodder ration.
With the help of WINLP application, the TMR fodder ration of a dairy cow with average dairy production and average body mass was compiled for each year of the time series. The concentrate % – forage % of the rations was also calculated for each year. On the basis of the concentrate % the Y_m value was estimated slightly below the average for 1985 (concentrate % = 16.4, Y_m = 0.05950). As regards 2005, concentrate % increased to 25.9% and the Y_m value was estimated as 0.058. The Y_m value was calculated with the help of interpolation for the years between, and of extrapolation for 2006-2008.
Non-Dairy Cattle - In the case of Non-Dairy Cattle the default parameters for Western Europe (Rev. 1996 IPCC Guidelines Ref. Manual (Table B-1, Page 4.39)) were used for the

calculations.
The worksheets "4.A EF DC" and "4.A EF NDC" in the calculation sheet (c2008_T2v01_201003081043.xls) contains the details of the calculation.

6.2.2.2 Livestock Population

The annual average population of livestock (Table 6.2 and 6.3) were determined on the basis of the basic data of the HCSO (three data collections per year: 1 April, 1 August and 1 December), according to the categories of the Rev. 1996 Guidelines. The annual average population was calculated by using the following formula:

$$NoA_{2007} = (0.5*NoA_{Dec2007}+NoA_{Apr2008}++NoA_{Aug2008}+0.5*NoA_{Dec2008})/3$$

(Equation 6.1.)

Where:

NoA_{2007} = average annual population in the given livestock category in 2008. [1'000 head]
$NoA_{Dec2006}$ = population in the given livestock category on 1 December 2007. [1'000 head]
$NoA_{Apr2007}$ = population in the given livestock category on 1 April 2008. [1'000 head]
$NoA_{Aug2007}$ = population in the given livestock category on 1 August 2008. [1'000 head]
$NoA_{Dec2007}$ = population in the given livestock category on 1 December 2008. [1'000 head]

Table 6.2. *Livestock population and its trend 1985-2008 (I)*

Year	Population size (1'000 heads)				
	Animal category				
	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats
1985	598	1,298	0.1	2,588	18
1986	579	1,226	0.1	2,454	18
1987	579	1,160	0.1	2,453	22
1988	573	1,155	0.1	2,327	26
1989	569	1,109	0.1	2,172	31
1990	560	1,053	0.1	1,958	35
1991	518	1,007	0.1	2,009	39
1992	472	809	0.1	1,867	50
1993	438	627	0.1	1,458	61
1994	403	549	0.1	1,089	71
1995	392	553	0.2	998	76
1996	396	535	0.3	930	81
1997	387	512	0.4	901	86
1998	381	494	0.5	954	90
1999	385	484	0.6	981	95
2000	390	443	0.7	1,225	97
2001	377	416	0.8	1,164	108
2002	345	431	0.9	1,133	96
2003	330	428	1.0	1,259	94
2004	309	424	1.1	1,380	85
2005	300	420	1.2	1,447	78
2006	275	428	1.3	1,358	81
2007	267	443	1.4	1,301	72
2008	264	436	1.4	1,270	73

Source: HCSO (2008)

Table 6.3. *Livestock population and its trend 1985-2008 (II)*

Year	Population size (1'000 heads)				
	Animal category				
	Horses	Asses and Mules	Swine	Total poultry	Other animals (Rabbits)
1985	103	5.0	8,931	82,030	2,238
1986	100	5.1	8,955	83,502	2,319
1987	93	5.0	8,876	82,914	2,400
1988	80	4.8	8,902	79,079	2,481
1989	79	4.6	8,457	74,591	2,562
1990	80	4.5	8,751	69,846	2,644
1991	84	4.3	7,558	57,540	2,978
1992	79	4.3	6,159	52,746	2,755
1993	75	4.3	5,760	44,013	2,096
1994	85	4.3	4,926	46,264	1,271
1995	75	4.3	5,089	45,092	1,378
1996	74	4.3	5,536	38,873	1,041
1997	76	4.3	4,953	45,874	933
1998	77	4.3	5,338	46,620	1,005
1999	78	4.3	5,585	40,722	912
2000	78	3.4	5,063	49,515	919
2001	65	3.6	4,821	52,116	1,138
2002	64	3.4	5,093	50,939	1,157
2003	62	3.3	5,049	53,550	1,148
2004	65	3.1	4,385	50,492	999
2005	67	2.6	4,022	46,405	1,003
2006	65	2.3	3,944	44,653	1,084
2007	59	2.1	4,037	43,162	1,055
2008	58	2.0	3,663	45,035	904

Source: HCSO (2008)

6.2.2.3 Emission Factors

CH_4 emission of Dairy Cattle and Non-Dairy Cattle categories were calculated on the basis of GPG 2000 Tier 2 method (GPG, Equation 4.14):

$$EF = (GE * Y_m * 365) / 55.65$$

(Equation 6.2)

Where:

EF	CH_4-emission factor [kg head^{-1} yr^{-1}]
GE	gross energy intake [MJ head^{-1} day^{-1}]
Y_m	methane conversion rate [MJ MJ^{-1}]
365	days of year [day yr^{-1}]
55.65	energy content of methane [MJ kg^{-1}]

In the case of Dairy Cattle category gross energy intake was determined on the basis of the data of the Hungarian Nutrition Codex, 2004. The methane conversion rate was estimated a bit under the average value within the range given in GPG2000 Table 4.8 (2007: 0.0579 [MJ MJ^{-1}], Range 1985-2007: 0.0579-0.0594), since concentrate/forage ratio is high in the case of dairy cattle in Hungary.

In the case of Non-Dairy Cattle category the default values of Rev. 1996 IPCC Guidelines

Ref. Manual (Table B-1, Page 4.40) were used for the Tier 2 calculations.
Table 6.4 and 6.5 summarizes the emission factors used for the calculations. In the case of Buffalo, Sheep, Goats, Horses, Asses & Mules, Swine, Poultry and Rabbits categories GPG Tier1 and IPCC default emission factors were used.

Table 6.4. *Annual milk yield, gross energy intake, methane conversion rate and emission factors for Dairy Cattle 1985-2008*

Year	Milk Yield	Gross Energy Intake	Methane Conversion Rate [Y_m]	CH_4-Emission Factor
	[kg cow^{-1} yr^{-1}]	[MJ head^{-1} yr^{-1}]	[MJ MJ^{-1}]	[kg head^{-1} yr^{-1}]
1985	4,518	273.98	0.05950	106.92
1986	4,757	277.67	0.05943	108.23
1987	4,849	279.52	0.05935	108.81
1988	4,996	281.36	0.05928	109.39
1989	5,015	279.52	0.05920	108.53
1990	5,068	283.21	0.05913	109.83
1991	4,789	279.52	0.05905	108.26
1992	4,865	281.36	0.05898	108.83
1993	4,738	281.36	0.05890	108.69
1994	4,786	281.36	0.05883	108.56
1995	5,025	285.05	0.05875	109.84
1996	4,977	285.05	0.05868	109.70
1997	5,120	288.74	0.05860	110.98
1998	5,507	294.28	0.05853	112.96
1999	5,453	294.28	0.05845	112.82
2000	5,479	294.28	0.05838	112.67
2001	5,665	297.97	0.05830	113.94
2002	6,161	305.35	0.05823	116.61
2003	6,154	305.35	0.05815	116.46
2004	6,131	307.19	0.05808	117.01
2005	6,429	310.88	0.05800	118.26
2006	6,682	314.57	0.05793	119.51
2007	6,874	318.26	0.05785	120.76
2008	6,971	322.88	0.05778	122.35

Table 6.5. *The emission factors used for the calculation of the methane emissions from enteric fermentation*

Animal category	CH_4-emission factor [kg head^{-1} yr-^{1}]	Comments
Dairy Cattle	see Table 6.4	*country specific value, Tier 2*
Non-dairy Cattle	53	*country specific value, Tier 2, Basis Rev. 1996 Guidelines, Ref. Man., Table B-1, p. 4.39*
Buffalo	55	*IPCC default value for developed countries*
Sheep	8	*IPCC default value for developed countries*
Goats	5	*IPCC default value for developed countries*
Horses	18	*IPCC default value for developed countries*
Asses & Mules	10	*IPCC default value for developed countries*
Swine	1.5	*IPCC default value for developed countries*
Poultry	0.015	*expert judgement, according to Minonzio et al. (1998)*
Rabbits	0.08	*expert judgement, according to NIR Italy*

6.2.3. Uncertainties and time-series consistency

See 6.1.4. and Table 6.1.

6.2.4. QA/QC Information

See 6.1.5.

6.2.5. Source-specific recalculations

Recalculation occurred in the following categories and years:

- 4.A Enteric Fermentation, CH_4 Emissions, 2000-2007 (new activity data for Asses and Mules and Poultry)

6.2.6. Planned improvements

In order to improve the used methodology in the inventory, the following measures are planned:

- In the Dairy Cattle category the estimations on weight will be checked through data collection in the practical production
- As regards Non-Dairy Cattle category country-specific parameters will be used in the next inventory within the frame of Tier 2 method
- As regards livestock category more detailed data will be used than the categories currently used for all those source categories where Tier 2 method is applied

(See also 6.1.7.)

6.3. Manure management (CRF sector 4. B.)

6.3.1. Source Category Description

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

Animal manure is an important source of CH_4 and N_2O. The amount of CH_4 and N_2O emitted from the manure to the atmosphere depends on the conditions of manure management and

use as well as on the composition of released excrements. In 2008 39.6% (CH_4) and 16.1% (N_2O) of the entire emissions from agriculture derived from this source category

6.3.2. Methodological issues

See chapter 6.2.2 and Table 6.2 and 6.3 regarding activity data.

CH_4 emissions generated from manure management (excluding Rabbits category) were estimated by using of GPG2000 Tier 2 method, emission factors were calculated in accordance with the GPG2000 (Equation 4.17):

$$EF_i = VS_i * 365 * B_{oi} * 0.67 * \Sigma_{(jk)} MCF_{jk} \bullet MS_{ijk}$$

(Equation 6.3)

Where

EF_i emission factor for livestock population i [kg head^{-1} yr^{-1}]

VS_i volatile solids excretion for livestock population i [kg head^{-1} day^{-1}]

365 Factor-1 [day yr^{-1}]

B_{oi} maximum CH_4 producing capacity for manure produced by animals in livestock population i [m^3 kg^{-1} VS]

0.64 Factor-1 [kg m^{-3}]

MCF_{jk} CH_4 conversion factors for each manure management system j by climate region k [kg kg^{-1}]

MS_{ijk} fraction of animal species/category i's manure handled using manure system j in climate region k

Table 6.6, 6.7, 6.8 and 6.9 contain parameters used for the calculations (VS, B_o, MCF, MS) and the CH_4 emission factors.

The value "VS of Dairy Cattle" was calculated according to the GPG 2000 (Equation 4.16, page 4.31).

$$VS = GE \bullet (1 \text{ kg-dm}/18.45 \text{ MJ}) \bullet (1 – DE/100) \bullet (1 – ASH/100)$$

Where

VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm head^{-1} day^{-1}

GE = Estimated daily average feed intake in MJ head^{-1} day^{-1}

DE = Digestible energy of the feed in percent

ASH = Ash content of the manure in percent

The "Estimated daily average feed intake in MJ/day (GE)" value was calculated on the basis provided in Chapter 6.2.2.1. In order to estimate the value "digestible energy of the feed in percent (DE)" the concentrate % (see 6.2.2.1) were used according to the following:

Concentrate %	DE %
13.00 – 16.99	65.0
17.00 – 22.00	67.5
Over 22.00	70.0

In the case of "Ash content of the manure in percent (ASH)" the default value (8%) was used. The worksheet "4.B MM DC" in the calculation sheet (c2008_T2v01_201003081043.xls) contains the details of the calculation.

Table 6.6. Volatile solids excretion rates and CH_4-emission factors for Manure Management for Dairy Cattle 1985-2008

Year	VS (Volatile Solid Excretion Rate)	CH_4-Emission Factor
	[kg DM day^{-1}]	[kg head^{-1} yr^{-1}]
1985	4.78	6.99
1986	4.85	7.09
1987	4.88	7.13
1988	4.91	7.18
1989	4.53	6.62
1990	4.59	6.71
1991	4.88	7.13
1992	4.91	7.18
1993	4.91	7.18
1994	4.91	7.18
1995	4.62	6.76
1996	4.97	7.27
1997	4.68	6.84
1998	4.77	6.97
1999	4.77	6.97
2000	4.77	6.97
2001	4.83	7.06
2002	4.57	6.68
2003	4.57	6.68
2004	4.60	6.72
2005	4.65	6.80
2006	4.71	6.88
2007	4.76	6.96
2008	4.83	7.06

Table 6.7. *Fraction of manure production per manure management systems, volatile solids excretion rate, maximum methane producing capacity and CH_4-emission factors for Manure Management (I)*

Fraction of manure production per manure management systems [kg kg-1]	Animal category				
	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats
Pasture range and paddock	0.08	0.15	0.40	0.40	0.40
Solid storage and dry lot	0.88	0.83	0.60	0.59	0.59
Liquid system	0.04	0.02	-	0.01	-
Other AWMS	-	-	-	-	0.01
VS (Volatile Solid Excretion Rate) [kg DM day^{-1}]	see Table 6.6	2.69	3.90	0.40	0.28
B_0 (Max CH_4-producing capacity) [m^3 kg^{-1} VS]	0.24	0.17	0.10	0.19	0.17
CH_4-emission factor [kg head^{-1} yr^{-1}]	see Table 6.6	1.89	0.95	0.25	0.12

Table 6.8. *Fraction of manure production per manure management systems, volatile solids excretion rate, maximum methane producing capacity and CH_4-emission factors for Manure Management (II)*

Fraction of manure production per manure management systems [kg kg-1]	Animal category				
	Horses	Asses and Mules	Swine	Total poultry	Other animals (Rabbits)
Pasture range and paddock	0.40	0.40	-	-	-
Solid storage and dry lot	0.60	0.60	0.25	0.74	1.00
Liquid system	-	-	0.25	0.26	-
Pit storage <1 month	-	-	0.25	-	-
Pit storage >1 month	-	-	0.25	-	-
VS (Volatile Solid Excretion Rate) [kg DM day^{-1}]	1.72	0.94	0.50	0.014	-
B_0 (Max CH_4-producing capacity) [m^3 kg^{-1} VS]	0.33	0.33	0.45	0.32	-
CH_4-emission factor [kg $head^{-1}$ yr^{-1}]	1.39	0.76	10.87	0.12	0.08

Table 6.9. *Methane conversion factors for manure management systems*

Manure Management System	MCF [kg kg^{-1}]
Pasture range and paddock	0.01
Solid storage and dry lot	0.01
Liquid system	0.39
Pit storage <1 month	0.00
Pit storage >1 month	0.39

Source: GPG(IPCC, 2000) Table 4.10, p.4.36

Table 6.10. *Amount of nitrogen excreted by each livestock category (N_{Ex})*

Animal Category	N_{ex} [kg $head^{-1}$ $year^{-1}$]	Comments
Other cattle	70	IPCC, Western Europe
Dairy cattle	100	IPCC, Western Europe
Buffalo	70	IPCC, Western Europe
Sheep	20	IPCC, Western Europe
Goats	18	Walther et al. (1994)
Horses	60	Walther et al. (1994)
Asses & Mules	25	IPCC, Western Europe
Swine	20	IPCC, Western Europe
Poultry	0.6	IPCC, Western Europe
Rabbits	4.1	EMEP-Corinair (2002)

Source: Revised Guidelines, Ref. Man., Table 4-20, p. 4.99, Walther et al. (1994), EMEP-Corinair (2002)
Notes: On the basis of expert consultations (Gundel 2004, Várhegyi 2004, Fébel 2007) and literature data (Várhegyiné et al. 1999, Babinszky et al. 2002, Fébel and Gundel 2007) it was asserted that production level and feeding technology of animal breeding in Hungary are close to the Western European standards, therefore the default IPCC factors for Western Europe were used.

There was no change in the estimation process of N_2O emissions, still Tier 1 method and the default N-excretion values and emission factors were used. Table 6.7, 6.8 and 6.10. summarise the data on the estimation of average annual nitrogen emissions of the individual livestock categories and of nitrogen excreted in the various manure management systems, while Table 6.11. presents the emission factors used for the calculation of N_2O emissions.

Table 6.11. *Emission factors used for the estimation of the N_2O emission from various manure management systems*

Manure management system	N_2O-N emission factor [kg N_2O-N kg^{-1} N_{ex}]
Pasture range and paddock	0.02
Solid storage and dry lot	0.02
Liquid system	0.001
Pit storage <1 month	0.001
Pit storage >1 month	0.001
Other AWMS	0.005

Source: GPG2000, Table 4-12, p. 4.43

As regards the analysis of the manure management systems the following should be noted:
The latest analysis on the distribution of the Hungarian manure management systems occurred in 2005. At that time the % proportions of the nitrogen generated in the different manure management systems were estimated on the basis of expert consultations (Mészáros 2000) and of the study ”Building capacity and capacity utilisation of animal production and the technical conditions of the major farms” (Ráki 2003, in Hungarian). The estimations of that time have been used since then.
Ráki (2003) processed three databases: the General Agricultural Census 2000 (HCSO), data from the legally required registration of agricultural producers in 2000 (this includes data for agricultural enterprises) and a registration 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 connection with the entire animal keeping sector because it covers 70% to 100% of the livestock populations depending on the given category.
The concrete values used for emission calculations were calculated on the basis of the ratios of places provided in the study (Ráki 2003) and of personal expert consultation (György Mészáros, Ministry for Agriculture and Rural Development, 2000, verbal communication). The following tables of the study served as the basis of the calculations:

Swine: Appendix 32 - 34; Page 93 - 95
Cattle: Appendix 53 - 55; Page 115 -117
Sheep: Appendix 75; Page 137
Poultry: Appendix 78 - 80; Page 139 – 40
Appendix 102 - 105; Page 152 – 153
Appendix 111 – 126; Page 156 – 162
Appendix 130 – 149; Page 165 – 172

For the remaining categories the expert estimation of Mészáros (2000) was used.

6.3.3. Uncertainties and time-series consistency

See 6.1.5. and Table 6.1.

6.3.4. QA/QC Information

See 6.1.4.

6.3.5. Source-specific recalculations

Recalculation occurred in the following categories and years:

- 4.B Manure Management, CH_4 and N_2O Emissions, 2000-2007 (new activity data for Asses and Mules and Poultry)

6.3.6. Planned improvements

The revision of the distribution data of manure management systems is planned since serious reconstructions have been carried out in the Hungarian agriculture sector affecting manure management systems since 2007. The revision is based on the data of General Agricultural Census planned to be performed in 2010 and expected to be published in 2011. (See also 6.1.7.)

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

6.4.1. Source Category Description

Emitted gas: CH_4
Key source: none

Hungary situated on the north edge of rice production area. According to this the climatic conditions are unfavorable. The production area of rice involves the poorer quality soils.
Since the production volume is very low in Hungary, the contribution of rice cultivation to the greenhouse gas emissions is minimal, only 0.4% of the entire CH_4 emissions from agriculture sector.

6.4.2. Methodological issues

In Hungary the rice is cultivated on poorer quality soil, without organic amendments, the fields are intermittently flooded. The aeration is applied as a pest control during the cultivation. (Apáti, 2003)
Methane emissions from rice cultivation were calculated according to the Equation 4.42 of the GPG (IPCC, 2000). Due to lack of detailed technological data on cropping technology the IPCC default factors were used for the calculation, according to the Table 4.22.
(EF= 20 g CH_4 m^{-2}; SF_0= 2; SF_s=1). For the scaling factor to water management 0.5 was applied, because of the intermittently flooded, single aeration water management technology. The total size of the production area was calculated on the basis of the official HCSO data.

6.4.3. Uncertainties and time-series consistency

See 6.1.4. and Table 6.1.

6.4.4. QA/QC Information

See 6.1.5.

6.4.5. Source-specific recalculations

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6.4.6. Planned improvements

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6.5. Agricultural soils (CRF sectors 4.D.1, 4.D.2 and 4.D.3)

6.5.1. Source Category Description

Emitted gas: N_2O
Key source: Direct: Level 1; Trend 1;
Indirect: Level 1; Trend 1

In 2008 agricultural soils emitted 83.9% of the N_2O emissions of agriculture.
N_2O emitted by soils is generated as an intermediary product of denitrification and a by-product of nitrification. 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). The most important factor affecting the N_2O emissions from agricultural soils is the amount of nitrogen released into the soils via animal manure, synthetic fertilizers, crop residues through deposition and N-fixing. Small changes in the environmental conditions may have a significant effect on the amount of generated N_2O.
[Note: for a detailed review on N_2O generation processes in soils, see also Granli et al. (1994), Bremner (1997) és Schmid et al., (2000).]

6.5.2. Methodological issues

The estimation of direct and indirect N_2O emissions was carried out on the basis of the GPG 2000, using the Tier 1b method. A certain part of the activity data for the sector was obtained directly from the database of the HCSO (livestock for calculating N excretion, total harvested production of plants, synthetic N-fertilizer use).
N_2O emissions from the categories of Direct Soil Emissions (from synthetic N-fertilizers, manure, N-fixing, crop residues and histosols), Emissions from Pasture, Range and Paddock Manure and Indirect Soil Emissions were calculated with the parameters summarized in Table 6.12. In order to calculate the amount of N in the frame of manure use and on pastures the data of Table 6.7, 6.8 and 6.10. (see also chapter 6.3.2) were also used beside Table 6.12.
The parameters used for the calculation were selected on the basis of the GPG 2000 default values (Table 4.16, Page 4.58). In the case of those plants being not contained by the mentioned Table the parameters of the similar plants were chosen (e.g. the factors of bean in the case of French bean). The worksheet "4.D.1.4 DSE_CR" in the calculation sheet (c2008_T2v01_201003081043.xls) contains the used parameters and the source thereof for the entire time series.

Trends of synthetic N-fertilizer use, N-excretion and total harvested production of plants are shown in Figure 6.5, 6.6 and 6.7.

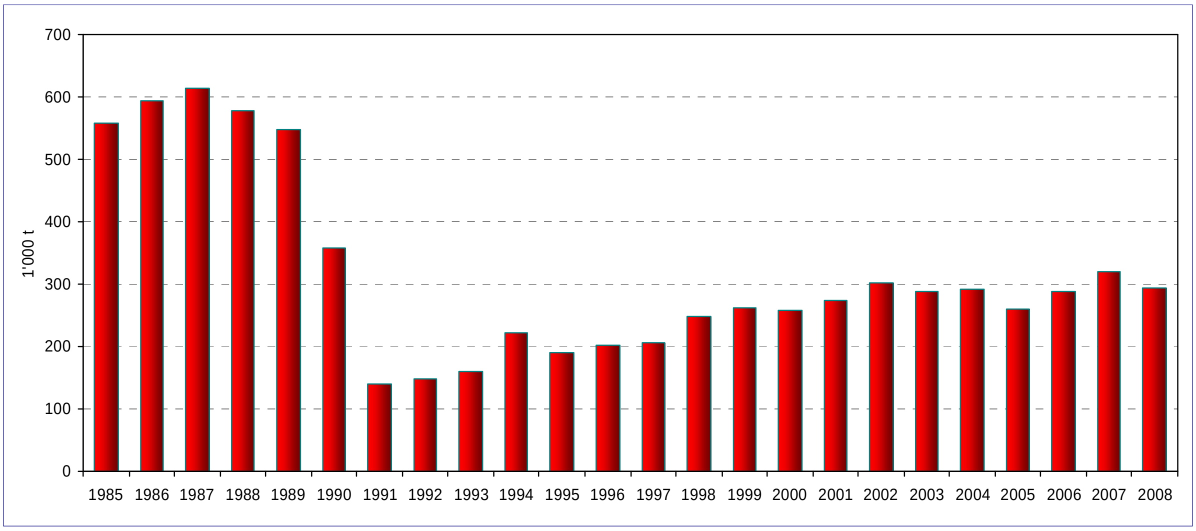

Figure 6.5. *Synthetic fertilizer nitrogen applied to soils*

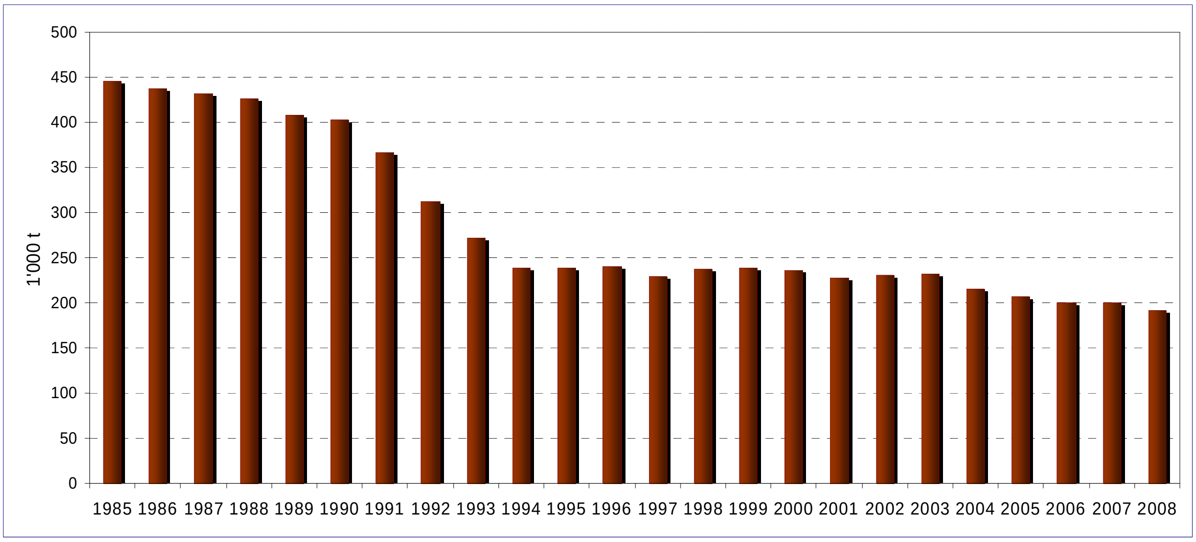

Figure 6.6. *Animal manure nitrogen excreted by livestock*

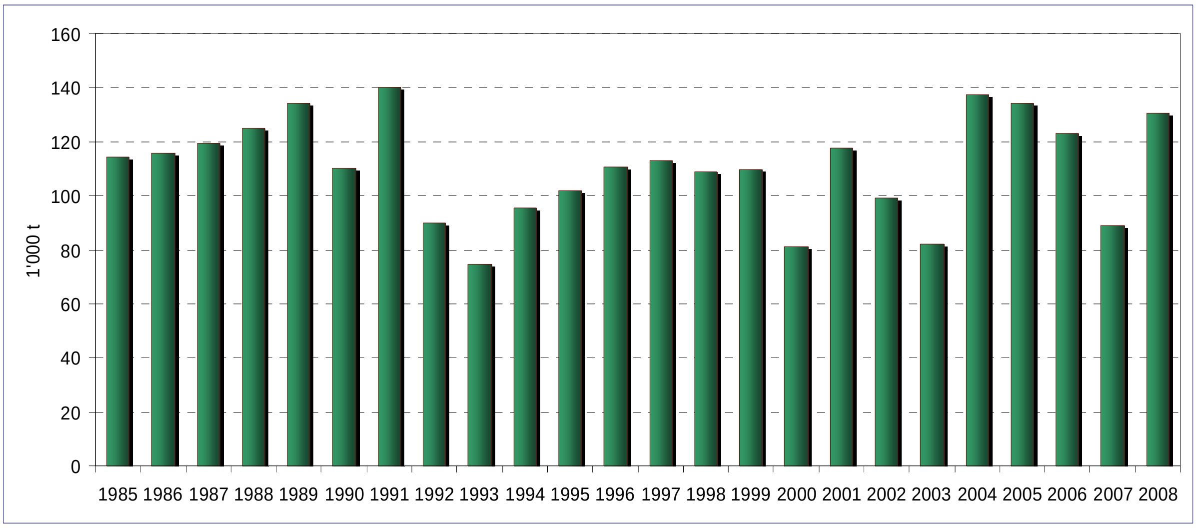

Figure 6.7. *Nitrogen input from crop residues*

Table 6.22. *Parameters and values used for the calculation of N_2O emissions from Agricultural Soils*

Parameter	Dimension	Value
Direct Soil Emissions – Fertilizer		
$Frac_{GASFS}$	$kg\ kg^{-1}$	0.1
F_{SN}	$kg\ yr^{-1}$	GPG Eq-4.22
EF_1	$kg\ kg^{-1}$	0.0125
Direct Soil Emissions – Animal manure		
$Frac_{GASM}$	$kg\ kg^{-1}$	0.2
$Frac_{FUEL-AM}$	$kg\ kg^{-1}$	0
$Frac_{PRP}$ (2008) Average (1985-2008) Min (1996) - Max (2005)	$kg\ kg^{-1}$	0.098421 0.087729 (0.077602 -0.099911)
$Frac_{FEED-AM}$	$kg\ kg^{-1}$	0
$Frac_{CNST-AM}$	$kg\ kg^{-1}$	0
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	$kg\ kg^{-1}$	1.50-2.10
Forage Crops		0
$Frac_{DM}$, N-fixing-crops	$kg\ kg^{-1}$	0.850-0.870
$Frac_{NRCBF}$	$kg\ kg^{-1}$	0.0142-0.0230
F_{BN}		
Non-forage Crops	$kg\ yr^{-1}$	GPG Eq-4.26
Forage Crops		GPG Eq-4.27
EF_1	$kg\ kg^{-1}$	0.0125

Table 6.22 (continued) *Parameters and values used for the calculation of N_2O emissions from Agricultural Soils*

Direct Soil Emissions – Crop Residues		
$Res_O/Crop_O$ Non-Forage Crops Forage Crops	kg kg^{-1}	0.3000-1.6000
$Frac_{DM}$, Non- N-fixing-crops	kg kg^{-1}	0.78-0.92
$Frac_{NCRO}$	kg kg^{-1}	0.0028-0.0228
$Res_{BF}/Crop_{BF}$ Non-Forage Crops Forage Crops	kg kg^{-1}	1.50-2.100
$Frac_{DM}$, 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
$Frac_{BURN}$ for Cereals 1985-1989		0.1103-0.0220
$Frac_{FUEL-CR}$	kg kg^{-1}	0
$Frac_{CNST-CR}$	kg kg^{-1}	0
$Frac_{FOD}$	kg kg^{-1}	0
F_{CR}	kg yr^{-1}	GPG Eq-4.26
EF_1	kg kg^{-1}	0.0125
Direct Soil Emissions – Pasture, Range and Paddock Manure		
$Frac_{PRP}$ (2008) Average (1985-2008) Min (1996) - Max (2005)	kg kg^{-1}	0.098421 0.087729 (0.077602 -0.099911)
EF_3	kg kg^{-1}	0.02
Indirect Soil Emissions – Atmospheric deposition		
$Frac_{GASFS}$	kg kg^{-1}	0.1
$Frac_{GASM}$	kg kg^{-1}	0.2
EF_4	kg kg^{-1}	0.01
Direct Soil Emissions – Leaching and Run-Off		
$Frac_{LEACH}$	kg kg^{-1}	0.3
EF_5	kg kg^{-1}	0.025

Table 6.33. *Activity data and input parameters used to estimate emissions from crop residues*

Crop	Annual Crop Product (t)	Residue/ Crop Product Ratio (t/t)	Dry Matter Fraction (t/t)	Nitrogen Fraction (t N/ t dm)
Wheat	5,630,833	1.3	0.85	0.0028
Maize	8,897,138	1	0.78	0.0081
Rice	9,985	1.6	0.85	0.0067
Barley	1,467,055	1.2	0.85	0.0043
Rye	112,493	1.6	0.9	0.0048
Oats	181,792	1.3	0.92	0.007
Triticale	503,369	1.3	0.85	0.0028
Other cereals	37,984	1.3	0.85	0.0028
Potatoes	683,935	0.4	0.85	0.011
Bean	1,649	2.1	0.855	0.023
Peas	45,991	1.5	0.87	0.0142
Soya-bean	74,143	2.1	0.865	0.023
Sunflower seed	1,468,083	1	0.85	0.015
Rape seed	654,706	1	0.85	0.015
Linseed	610	1	0.85	0.015
Poppy seed	759	1	0.85	0.015
Sugar-beet	573,160	0.3	0.85	0.0228
Lucerne seed	512	1	0.85	0.015
Seeds of grass	1,480	1	0.85	0.015
Tomatoes	205,957	0.4	0.85	0.011
Cucumber	55,382	0.4	0.85	0.011
Watermelon	224,380	0.4	0.85	0.011
Melon	14,157	0.4	0.85	0.011
Green peas	117,771	1.5	0.87	0.0142
Green beans	31,649	2.1	0.855	0.023
Sweet pepper	148,304	0.4	0.85	0.011
Bonnet pepper	17,719	0.4	0.85	0.011
Sweet corn	536,582	1	0.78	0.0081
Hungarian red paprika	12,115	0.4	0.85	0.011

6.5.3. Uncertainties and time-series consistency

See 6.1.4. and Table 6.1.

6.5.4. QA/QC Information

See 6.1.5.

6.5.5. Source-specific recalculations

Recalculation occurred in the following categories and years:

- 4.D.1.2 Agricultural Soils, Direct N_2O-Emissions, Animal Manure Applied to Soils, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1985-2007 (values for ResO/CropO corrected)
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1986-2007 (Correction of calculation error in relation of rice and other cereals)
- 4.D.2 Agricultural Soils, Direct N_2O-Emissions, Pasture, Range and Paddock Manure, 2000-2007 (new activity data for Asses and Mules)
- 4.D.3.1 Agricultural Soils, Indirect N_2O-Emissions, Atmospheric Deposition, 2000-2007 (new activity data for Asses and Mules and Poultry)
- 4.D.3.2 Agricultural Soils, Indirect N_2O-Emissions, Nitrogen Leaching and Run-off, 2000-2007 (new activity data for Asses and Mules and Poultry)

6.5.6. Planned improvements

Elaboration of country-specific values for all livestock categories regarding N-excretion. (See also 6.1.7)

6.6. Field burning of agricultural residues (CRF Sector 4.F.)

6.6.1. Source Category Description

Emitted gases: CH_4, N_2O
Key source: none

In Hungary field burning of agricultural residues has been bound to permit by the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers being in force between 1986 and 2001. The condition for a permit was the case of plant health emergency. The Decree of Government No. 21/2001. (II. 14.) came into force in 2001 explicitly bans field burning of agricultural residues (the new regulation still keeps the possibility of field burning in the case of plant health emergency by a permit). So according to the abovementioned facts it was thought that there is no legal field burning in Hungary since the Regulation No. 21/1986. (VI. 2.) of the Council of Ministers has come to force. 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 crops (i.e., not the entire arable area) is affected by illegal burning (Sári 2003, verbal communication), therefore it was taken into account only between 1985 and 1989, and it was considered as negligible in the period after 1990.

6.6.2. Methodological issues

Until the middle of the 1980s, field burning was quite wide-spread. In the lack of reliable and quantitative information, it was assumed that the rate of field burning in crop cultivation areas had been gradually decreasing between 1985 and 1989, and was essentially eliminated in 1990. Accordingly, for the mentioned period between 1985 and 1990 the following values for crops were used as the proportion of biomass burnt on field: $Frac_{BURN}$ = 0.11, 0.09, 0.07, 0.04 and 0.02 (it meant for all plants produced: $Frac_{BURN}$ = 0.05, 0.04, 0.03, 0.02 and 0.01). As regards other parameters required for the calculation (dry matter, product/by-product ratio, C to N ratio), the default values indicated in the Revised Guidelines (Ref. Manual, Table 4-17, p. 4.65, p. 4.83) were used.

6.6.3. Uncertainties and time-series consistency
See 6.1.4. and Table 6.1.

6.6.4. QA/QC Information
See 6.1.5.

6.6.5. Source-specific recalculations
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6.6.6. Planned improvements
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7. Land-Use, Land-Use Change and Forestry (CRF sector 5.)

7.1. Overview of the sector

7.1.1. Description and quantitative overview

The greenhouse gas inventory of the Land Use, Land-Use Change and Forestry (LULUCF) sector comprises the emissions and removals of CO_2 with respect to overall carbon gain or loss in the relevant carbon pools of the defined 6 land-use categories. The liming of agricultural lands is included in the LULUCF sector as well. The non-CO2 emissions are also to be reported for biomass burning here. These activities resulted in 4,574.76 Gg net removal of CO_2 equivalent in 2008.
The methodology used to calculate emissions and removals from this category follows that of the IPCC Good Practice Guidance for LULUCF (IPCC, 2003), which suggests the use of the six top level land categories, split into remaining in the land-use category and converted to another land use category. In previous submissions area of Hungary was reported using the Approach 1 area representation method. Now, the land-use changes are specified due to the inclusion of new supplementary data, thereby allowing the application of an improved area representation method.
In the 2008 inventory submission Hungary reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 5.A), Cropland (CRF 5.B), Grassland (CRF 5.C) and Other Land (CRF 5F). In category 5.A Forest Land carbon stock change in living biomass is reported. In category 5.B Cropland carbon stock changes in living (woody) biomass and mineral soils are reported. In category 5.C Grassland and 5.F Other Land carbon stock change in mineral soils are reported. N_2O emissions from agricultural soils and fertilization (CRF 5(I)) are reported under the Agriculture sector (CRF 4). In addition, CO_2 emission from liming is reported in CRF table 5(IV) and CO, CH_4, N_2O and NO_x emissions from biomass burning are reported in CRF table 5(V).
The LULUCF sector report does not include emission estimates from Wetlands (CRF 5.D) and Settlements (CRF 5.E). In these categories only area data are reported. Non-CO_2 emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported as drainage is a very rare activity in Hungary. N_2O emission from disturbance associated with land-use conversion to Cropland (CRF 5(III)) has not yet been reported due to lack of available data. In Hungary, organic soils are not in use for agricultural purposes, so emissions from organic soils are not reported.
The LULUCF sector in 2008 was a net sink of 4,574.76 Gg CO_2–eq, because the total emissions arising from the sector were smaller than the total removals (Table 7.1, Figure 7.1). The LULUCF sector is a net sink of CO_2 in Hungary in all years. Figures of previous NIR submission differs from the figures in this report due to recalculations. The large sink is mainly due to fact that the total increment of the growing stock in forest lands has been higher then the annual harvest. In 2008, the net sink in living biomass in forests was 4,992.15 Gg CO_2.
The living woody biomass in croplands was a source of 171.75 Gg CO_2 due to the higher removal than plantation in vineyards. Overall, the mineral soils in Hungary were sources of CO_2 (212.43 Gg). Mineral soils of Cropland and Grassland were sources and Other Land category was a sink of carbon in Hungary during the last few years. The liming in agricultural soils added up to 9.70 Gg CO_2 emissions in 2008. In addition, the non-CO_2 emission from biomass burning in forests was 23.51 Gg CO_2-eq. The estimates of emissions and removals from LULUCF over the period 1985-2008 are presented in Table 7.1.

Table 7.1 *Emissions and removals from LULUCF 1985-2008 (Gg)*

	1985	BY	1986	1987	1988	1989	1990	1991	
CO_2	-127	-2,214	-3,082	-3,468	-4,457	-3,669	-2,910	-3,360	
CH_4	1.17	1.16	1.18	1.14	1.10	1.10	1.02	0.99	
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
NO_x	0.29	0.29	0.29	0.28	0.27	0.27	0.25	0.25	
CO	10.20	10.16	10.33	9.95	9.65	9.63	8.89	8.66	
	1992	1993	1994	1995	1996	1997	1998	1999	
CO_2	-4,425	-6,275	-6,751	-6,796	-2,889	-2,957	-3,986	-2,352	
CH_4	0.9058	0.8	0.82	0.8544	0.929	0.9465	0.9223	0.9773	
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
NO_x	0.2251	0.1988	0.2033	0.2124	0.2309	0.2353	0.2292	0.24	
CO	7.9263	7.0005	7.1579	7.4766	8.1299	8.2832	8.0709	8.5525	
	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2	-1,307	-2,641	-1,857	-3,612	-2,628	-4,666	-2,665	-2,972	-4,598
CH_4	1.31	1.18	1.19	1.17	1.02	1.62	1.02	1.46	1.02
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NO_x	0.33	0.29	0.30	0.29	0.25	0.40	0.25	0.36	0.25
CO	11.45	10.35	10.41	10.27	8.89	14.16	8.93	12.74	8.90

In 2008 removals from LULUCF corresponded to approximately 6 percent of the total GHG emissions in Hungary (excluding LULUCF), compared to its 2 % in the base year. Removals from LULUCF were fluctuating over the period 1985-2008 (Figure 7.1).

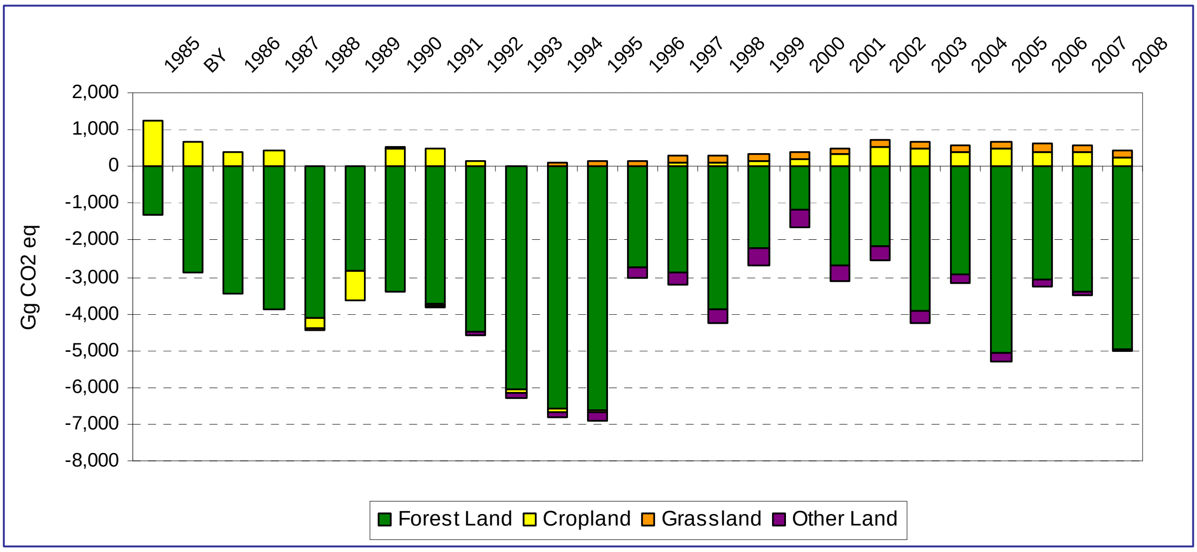


Figure 7.1 *Trend in emissions and removals from LULUCF 1985-2008*

7.1.2. Land area representation used in the Hungarian Inventory

The land-use categories in the Hungarian inventory are consistent with the GPG for LULUCF (IPCC, 2003) requirements. The reported land area is the average of the official land area of Hungary published by the HCSO's land-use statistics (9,303,266 ha). There are little

changes in the annually reported total land area in land-use statistics due to the movements of natural borders of Hungary and improvements of mapping techniques. To avoid inconsistency, the average of the annually published total areas is reported in the GHG inventory.
Coverage of the IPCC land-use categories required the compilation of different activity data obtained from different statistical surveys in Hungary.
The main sources of activity data were the National Forest Inventory (Central Agricultural Office Forest Directorate), the land-use statistics of the Hungarian Central Statistical Office, (HCSO) the CORINE land-cover inventories and land-cover change databases results of satellite images processing.
Forest inventory (National Forestry Database, NFD) provides the data for our estimates for Forest land. NFD comprises data on the whole forested area of the country regardless of proprietary relations. The survey is continuous; approximately 10 percent of the whole forested area is renewed annually, and the whole forested area is surveyed in a 10-year-long cycle. The inventory is stand-based, the average size of a forest compartment is about 4 ha, and the spatial resolution of mapping of forests is 0.1 ha. The NFD did not provide information on land-use categories before afforestation and after deforestation until 2007. The initial and final land-use data have been collected since 2008.
The second most important data source is the HCSO's land-use statistics. The annual census is published via the internet, on the website of the HCSO (http://portal.ksh.hu/pls/ksh/docs/eng/agrar/html/tabl1_3_1.html). The HCSO's land-use statistics records the whole official area of the country divided into nine land-use categories. However, lands not in use for agricultural purposes are reported aggregately as uncultivated land area. The data acquisition is based on questionnaires, and it is available since 1853, although there have been changes in the methodology since the beginning of the data collection (Kecskés, 1997). To ensure the consistency, the data set was adjusted according to the methodological changes. This data set contains only the net changes of the different land-use categories.
The HCSO's land-use statistics is the unique unified land-use data set for Hungary for the whole inventory time series. It records the whole area of the country but this is an agricultural survey, therefore it does not contain information on Settlements, and Wetlands. (Although Fishponds and Reeds are reported in it, but these categories are only small parts of the IPCC Wetlands category.) Settlements and Wetlands are rather land cover than land-use categories therefore they were determined using the CORINE land-cover databases for the reference years 1990, 2000, 2006. The annual data were interpolated from these databases.
The HCSO's land-use statistics does not contain information on the specification of land-use changes. Only the net area data are available for the different categories in it. Unified data set for land-use changes for the whole inventory period is not available, but the CORINE land-cover data set (for the reference years of 1990-2000, 2000-2006) contain information on the land-cover changes for all the IPCC categories. Nevertheless, the difference between the 'land-use' and 'land-cover' can cause some discrepancies. The two CORINE land-cover change database were supplemented by a third, auxiliary land-cover change database for the years of 1985-1990. This data set is similar to the other CORINE land cover change data sets and it was produced via processing satellite images specifically for GHG inventory purposes by the Institute of Geodesy, Cartography and Remote Sensing. For more details see the technical documentation of the project (Kosztra, 2009). It is important to note that the minimal extension of the area is 25 ha in the CORINE land-cover database, but it is 5 ha in the land-cover change databases. (CLC2000 Hungary Final Report, CLC2006 Hungary Final Report)
In the compilation of land-use change matrices, the different statistical surveys were treated hierarchically, as follows:

1. National Forestry Database
2. HCSO land-use statistics
3. CORINE land-cover inventories and land-cover change databases and processing of satellite images

National application of IPCC land use categories in the Hungarian inventory and land use change matrices

Forest

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. On the other hand, „forest land" includes forests, as well as roads and other areas that are under forest management, but that are not covered by trees.
Regarding the data sources, the activity data was taken from the National Forestry Database of the Central Agricultural Office Forest Directorate (the former National Forest Service).

Cropland

Cropland area contains the arable lands, kitchen garden[3], orchards and the vineyard areas, which are reported in the "land area of Hungary by land use categories" statistics of the HCSO. The definitions of the four above mentioned subcategories are the following:
Arable land: any land area under regular cultivation irrespective of the soil cultivation and whether the area is under crop production or not due to any reason, such as inland waters or fallow. Area under tree nurseries (including ornamental and orchard tree nurseries, vineyard nurseries, forest tree nurseries, but excluding those for the holdings' own requirements grown in the forest), permanent crops (e.g. alfalfa and strawberries), herbs and aromatic crops are included. Area of kitchen gardens utilised for crop and horticultural production is included only if it is not devoted for the own consumption of the people living on the holding.
Kitchen garden is usually an area around the house separated from the rest of the farm used primarily for production for the own consumption of people belonging to the farm; any surplus of low amount is for selling.
Orchard: land area under fruit trees and bushes, where the main crops are fruit trees and bushes. Orchard area may include several fruit species (e.g.: apples, pears, cherries, etc.) orchard includes not productive orchards as well. In the framework of statistical observation orchard land use category includes coherent orchards in kitchen gardens (with equal row width and plant spacing), if the area is 200 m^2 or above in case of berries and 400 m^2 or above in case of fruit trees.
Vineyard areas, where the grapes are planted in equal row width and planting space and the main crops are grapes. Vineyard can include more grape varieties, and includes not productive areas as well. Vineyard also includes vineyard areas in kitchen gardens (trellises), if the area is planted coherently (equal row width and planting space) and is at least of 200 m^2 in area.
It should be noted, that the HCS's land use statistics reports the set-asides in the Cropland category for five years after the abandonment. Set-asides which were abandoned more then five years are reported as areas not in use for agricultural purposes in the HCSO's land use statistics. Therefore in the GHG inventory the set-asides are reported in 5.F Other Land category.

Grassland

Grassland area refers to the Grassland (meadow and pasture) area is reported in the "Land area of Hungary by land use categories" statistics of HCSO. Land area utilised as meadow or pasture.
Meadow: land area under grass (artificial planting included), and the production is utilised by cutting, irrespective of whether it is used for grazing sometimes.
Pasture: land area under grass (artificial planting included) utilised for grazing irrespective of

[3] In Hungarian terms kitchen garden means vegetable garden.

whether it is used for cutting sometimes. Land areas under grass with trees utilised for grazing are included.
It should be noted; that this category contains the grassland in use, the natural grasslands which are not in use for agricultural purposes is reported in other land category according to the HCSO's land-use statistics.

Wetlands
Wetland area matches to the wetlands and water body categories of the CORINE land-cover databases. It contains the inland marshes (low-lying land usually flooded in winter, and more or less saturated by water all year round), peat bogs (peat land consisting mainly decomposed moss and vegetable matter. May or may not be exploited), water courses (natural or artificial water-courses including those serving as water drainage), water bodies (natural or artificial lakes, ponds etc.).
This category contains all the wetlands in Hungary. For separation of peat lands and flooded lands as managed wetlands by GPG for LULUCF (IPCC, 2003), further data are needed. (The most peat land areas are protected in Hungary, thus the peat extraction has been rolled back over the recent decades. The peat extraction is negligible in Hungary.)

Settlements
This category match to the 'Artificial surfaces' category of the CORINE land-cover database, which comprises the urban areas, industrial, commercial and transport units; mine, dump and construction sites and artificial non agricultural vegetated areas.

Other Land
To ensure the consistency regarding the Hungarian area the Other Land sub-category comprises the remaining land areas, which do not fall into any of the other five categories.
The other land area is the residual land area of the country after the other land-use categories have been accounted. It represents the difference between the sum of the areas of the other five categories and the total area of Hungary.
Abandoned meadows, pastures and set-asides are reported in this category as well.

Table 7.2 shows the land-use changes over the period 1985 to 2008 in the form of land-use change matrices for the individual years relative to the official national area of Hungary. It should be noted, that a rolling 20-year transition period that began in 1985 were taken into account in the calculation of the areas of the remaining and converted to categories. (Except the forest land category, where the transition period depends on tree species, and the set-asides in the Other Land category, where a transition period of ten years was applied.)

***Table 7.2** Land Use Matrices 1985-2008 (ha)*

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	
Forest Land	1,715,260	IE	IE	IE	IE	IE	
Cropland	40,380	5,280,916	5,256	0	772	0	
Grassland	IE	4,889	1,241,007	0	364	16,842	
Wetlands	IE	0	0	261,805	13	0	
Settlements	IE	9	114	0	522,194	5	
Other Land	IE	7,305	7	327	74	205,357	
1985	**1,755,640**	**5,293,300**	**1,246,400**	**262,132**	**523,569**	**222,224**	**9,303,266**
Forest Land	1,727,263	IE	IE	IE	IE	IE	
Cropland	38,570	5,272,434	10,513	0	1,545	0	
Grassland	IE	9,778	1,222,914	0	727	27,883	
Wetlands	IE	0	0	261,780	27	0	
Settlements	IE	18	229	0	522,042	9	
Other Land	IE	7,307	14	650	147	198,677	
1986	**1,765,833**	**5,289,900**	**1,233,700**	**262,430**	**524,792**	**226,611**	**9,303,266**
Forest Land	1,737,913	IE	IE	IE	IE	IE	
Cropland	38,778	5,264,007	10,513	0	2,317	4,999	
Grassland	IE	17,112	1,211,377	0	1,091	29,924	
Wetlands	IE	0	0	261,755	40	0	
Settlements	IE	28	343	0	521,889	14	
Other Land	IE	7,309	21	973	221	191,533	
1987	**1,776,691**	**5,289,000**	**1,222,300**	**262,728**	**526,014**	**226,533**	**9,303,266**
Forest Land	1,747,732	IE	IE	IE	IE	IE	
Cropland	39,875	5,254,880	10,513	0	3,089	10,697	
Grassland	IE	24,445	1,198,840	0	1,455	32,965	
Wetlands	IE	0	0	261,730	53	0	
Settlements	IE	37	457	0	521,736	18	
Other Land	IE	7,311	28	1,297	295	184,331	
1988	**1,787,607**	**5,287,400**	**1,209,900**	**263,027**	**527,236**	**228,096**	**9,303,266**
Forest Land	1,760,872	IE	IE	IE	IE	IE	
Cropland	40,563	5,246,554	10,513	0	3,861	15,596	
Grassland	IE	31,779	1,186,104	0	1,819	36,206	
Wetlands	IE	0	0	261,701	67	0	
Settlements	IE	46	572	0	521,583	23	
Other Land	IE	7,314	35	1,624	369	174,218	
1989	**1,801,435**	**5,286,600**	**1,197,300**	**263,325**	**528,458**	**226,148**	**9,303,266**
Forest Land	1,774,548	IE	IE	IE	IE	IE	
Cropland	39,354	5,240,027	10,513	0	4,634	18,694	
Grassland	IE	39,112	1,174,267	0	2,182	38,547	
Wetlands	IE	0	0	261,675	80	0	
Settlements	IE	55	686	0	521,430	27	
Other Land	IE	7,316	42	1,949	442	165,466	
1990	**1,813,902**	**5,287,600**	**1,185,600**	**263,623**	**529,681**	**222,860**	**9,303,266**
Forest Land	1,785,815	IE	IE	IE	IE	IE	
Cropland	39,589	5,190,647	26,282	0	5,406	48,877	
Grassland	IE	39,112	1,144,921	0	2,546	65,730	
Wetlands	IE	0	0	261,649	94	0	
Settlements	IE	64	800	0	521,277	32	
Other Land	IE	7,318	49	2,273	516	157,679	
1991	**1,825,404**	**5,238,413**	**1,172,160**	**263,921**	**530,903**	**272,465**	**9,303,266**
Forest Land	1,800,111	IE	IE	IE	IE	IE	
Cropland	38,228	5,141,267	42,051	0	6,178	79,060	
Grassland	IE	39,112	1,115,575	0	2,910	92,914	
Wetlands	IE	0	0	261,621	107	0	
Settlements	IE	74	914	0	521,125	36	
Other Land	IE	7,320	56	2,599	590	148,457	

Table 7.2 (continued) Land Use Matrices 1985-2008 (ha)

1992	**1,838,339**	**5,189,225**	**1,158,720**	**264,220**	**532,125**	**320,636**	**9,303,266**
Forest Land	1,814,240	IE	IE	IE	IE	IE	
Cropland	32,098	5,083,822	48,142	0	7,001	127,109	
Grassland	IE	47,249	1,095,339	0	3,180	103,576	
Wetlands	IE	0	0	261,599	114	0	
Settlements	IE	102	1,083	0	520,850	37	
Other Land	IE	7,364	418	4,263	2,255	140,063	
1993	**1,846,338**	**5,140,038**	**1,145,280**	**265,862**	**534,707**	**371,040**	**9,303,266**
Forest Land	1,824,982	IE	IE	IE	IE	IE	
Cropland	27,159	5,026,377	54,233	0	7,824	175,158	
Grassland	IE	55,385	1,075,104	0	3,450	114,482	
Wetlands	IE	0	0	261,581	122	0	
Settlements	IE	129	1,252	0	520,575	38	
Other Land	IE	7,407	780	5,924	3,921	133,623	
1994	**1,852,141**	**5,090,851**	**1,131,840**	**267,505**	**537,289**	**423,640**	**9,303,266**
Forest Land	1,836,869	IE	IE	IE	IE	IE	
Cropland	24,552	4,968,932	60,324	0	8,647	223,207	
Grassland	IE	63,521	1,054,868	0	3,719	124,901	
Wetlands	IE	0	0	261,557	129	0	
Settlements	IE	157	1,420	0	520,300	40	
Other Land	IE	7,450	1,142	7,591	5,586	124,191	
1995	**1,861,421**	**5,041,664**	**1,118,400**	**269,147**	**539,871**	**472,762**	**9,303,266**
Forest Land	1,847,447	IE	IE	IE	IE	IE	
Cropland	24,299	4,911,487	66,416	0	9,470	271,257	
Grassland	IE	71,657	1,034,632	0	3,989	135,563	
Wetlands	IE	0	0	261,531	136	0	
Settlements	IE	185	1,589	0	520,025	41	
Other Land	IE	7,494	1,503	9,259	7,251	113,471	
1996	**1,871,746**	**4,992,476**	**1,104,960**	**270,790**	**542,454**	**520,840**	**9,303,266**
Forest Land	1,857,227	IE	IE	IE	IE	IE	
Cropland	26,342	4,854,043	72,507	0	10,292	314,307	
Grassland	IE	79,794	1,014,396	0	4,259	146,225	
Wetlands	IE	0	0	261,502	144	0	
Settlements	IE	213	1,757	0	519,750	42	
Other Land	IE	7,537	1,865	10,931	8,917	106,251	
1997	**1,883,569**	**4,943,289**	**1,091,520**	**272,433**	**545,036**	**567,419**	**9,303,266**
Forest Land	1,865,328	IE	IE	IE	IE	IE	
Cropland	28,634	4,796,598	78,598	0	11,115	356,658	
Grassland	IE	87,930	994,160	0	4,529	156,888	
Wetlands	IE	0	0	261,476	151	0	
Settlements	IE	241	1,926	0	519,475	43	
Other Land	IE	7,580	2,227	12,600	10,582	101,161	
1998	**1,893,962**	**4,894,102**	**1,078,080**	**274,075**	**547,618**	**615,429**	**9,303,266**
Forest Land	1,876,618	IE	IE	IE	IE	IE	
Cropland	30,894	4,739,153	84,689	0	11,938	399,808	
Grassland	IE	96,066	973,925	0	4,799	167,550	
Wetlands	IE	0	0	261,444	159	0	
Settlements	IE	269	2,094	0	519,200	45	
Other Land	IE	7,624	2,589	14,274	12,247	92,114	
1999	**1,907,512**	**4,844,915**	**1,064,640**	**275,718**	**550,200**	**660,281**	**9,303,266**
Forest Land	1,889,854	IE	IE	IE	IE	IE	
Cropland	31,316	4,681,708	90,780	0	12,761	444,759	
Grassland	IE	104,202	953,689	0	5,069	178,213	
Wetlands	IE	0	0	261,412	166	0	
Settlements	IE	297	2,263	0	518,925	46	
Other Land	IE	7,667	2,951	15,948	12,644	82,430	
2000	**1,921,170**	**4,795,727**	**1,051,200**	**277,360**	**551,513**	**706,296**	**9,303,266**
Forest Land	1,900,546	IE	IE	IE	IE	IE	
Cropland	36,398	4,672,097	92,579	0	14,519	414,576	
Grassland	IE	107,168	945,596	0	5,549	180,622	
Wetlands	IE	0	0	258,750	198	2,613	
Settlements	IE	298	2,378	0	517,288	1,481	

***Table 7.2** (continued) Land Use Matrices 1985-2008 (ha)*

Other Land	IE	11,017	2,997	15,986	12,934	100,994	
2001	**1,936,944**	**4,792,500**	**1,045,083**	**274,736**	**552,826**	**701,176**	**9,303,266**
Forest Land	1,912,927	IE	IE	IE	IE	IE	
Cropland	42,253	4,662,486	94,378	0	16,276	384,393	
Grassland	IE	110,134	937,503	0	6,029	183,031	
Wetlands	IE	0	0	256,086	230	5,227	
Settlements	IE	300	2,492	0	515,650	2,915	
Other Land	IE	17,056	3,042	16,027	13,224	114,407	
2002	**1,955,180**	**4,791,963**	**1,038,967**	**272,112**	**554,139**	**690,905**	**9,303,266**
Forest Land	1,923,327	IE	IE	IE	IE	IE	
Cropland	44,246	4,652,875	96,177	0	18,034	336,344	
Grassland	IE	113,100	929,410	0	6,510	185,441	
Wetlands	IE	0	0	253,427	261	7,840	
Settlements	IE	301	2,607	0	514,013	4,350	
Other Land	IE	23,096	3,088	16,061	13,514	151,529	
2003	**1,967,573**	**4,791,426**	**1,032,850**	**269,488**	**555,452**	**686,477**	**9,303,266**
Forest Land	1,936,722	IE	IE	IE	IE	IE	
Cropland	44,180	4,643,265	97,976	0	19,791	288,295	
Grassland	IE	116,066	921,317	0	6,990	187,850	
Wetlands	IE	0	0	250,768	293	10,454	
Settlements	IE	302	2,721	0	512,375	5,785	
Other Land	IE	29,136	3,134	16,097	13,804	187,716	
2004	**1,980,902**	**4,790,889**	**1,026,733**	**266,864**	**556,765**	**681,113**	**9,303,266**
Forest Land	1,940,331	IE	IE	IE	IE	IE	
Cropland	42,949	4,650,028	94,518	0	20,777	240,246	
Grassland	IE	114,143	918,617	0	7,106	175,189	
Wetlands	IE	0	0	248,447	311	13,067	
Settlements	IE	294	2,722	0	512,154	7,215	
Other Land	IE	23,881	3,173	15,793	13,979	249,949	
2005	**1,983,280**	**4,790,351**	**1,020,617**	**264,240**	**558,078**	**686,700**	**9,303,266**
Forest Land	1,953,956	IE	IE	IE	IE	IE	
Cropland	44,516	4,645,499	91,061	0	21,762	192,197	
Grassland	IE	112,219	915,917	0	7,223	166,557	
Wetlands	IE	0	0	246,108	330	15,680	
Settlements	IE	287	2,722	0	511,892	8,645	
Other Land	IE	29,919	3,211	15,508	14,195	295,339	
2006	**1,998,472**	**4,789,814**	**1,014,500**	**261,616**	**559,391**	**679,472**	**9,303,266**
Forest Land	1,968,840	IE	IE	IE	IE	IE	
Cropland	50,354	4,644,079	92,860	0	22,747	144,147	
Grassland	IE	107,852	905,916	0	7,339	169,266	
Wetlands	IE	0	0	243,765	348	18,294	
Settlements	IE	279	2,722	0	511,636	10,075	
Other Land	IE	30,921	9,062	15,228	14,405	324,462	
2007	**2,019,194**	**4,784,907**	**1,012,150**	**258,992**	**560,704**	**667,319**	**9,303,266**
Forest Land	1,978,854	IE	IE	IE	IE	IE	
Cropland	51,975	4,642,660	94,659	0	23,733	96,098	
Grassland	IE	103,484	900,664	0	7,456	166,225	
Wetlands	IE	0	0	241,431	367	20,907	
Settlements	IE	271	2,723	0	511,380	11,506	
Other Land	IE	31,924	10,163	14,938	14,614	368,421	
2008	**2,030,830**	**4,780,000**	**1,009,800**	**256,368**	**562,016**	**664,252**	**9,303,266**

The figure 7.2 shows the distribution of the net areas of the six, broad IPCC land-use categories in Hungary, in 2008.

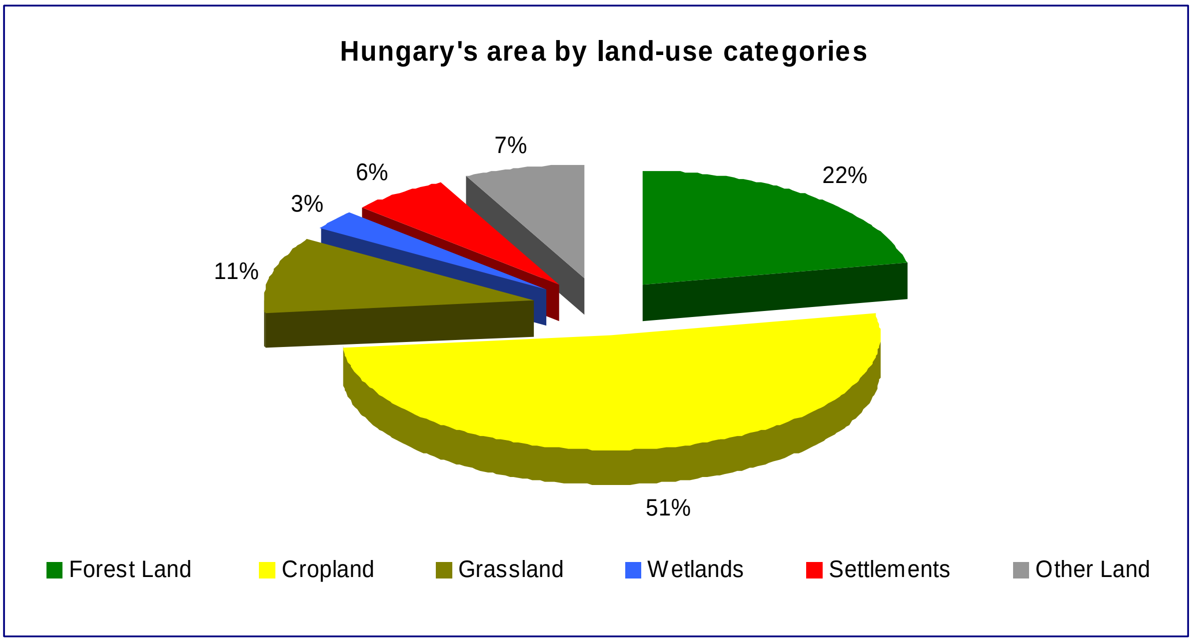


Figure 7.2 *Distribution of IPCC land-use categories in Hungary in 2008*

7.2. Forest Land (CRF sector 5.A)

A general description of the Hungarian forests and forestry in English can be found at http://84.206.26.187/en/specialities/erdeszet. Further data and information, mainly in Hungarian, can also be found on the website of the Central Agricultural Office Forest Directorate at http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag. Further data and information were also used that are not at the website, rather, in documents that are found in the documentation of the inventory.
Forests cover more than one fifth of the terrestrial area of the country. The total forest land area includes forest sub compartments that at least potentially are covered by trees, as well as unstocked areas like roads, openings, wildlife forage grounds, glades, buildings serving forest management purposes etc.). The area of forest land using this definition was 2,030.8 thousand ha by the end of 2008. Note that, earlier, we only reported the stocked area (see below), however, from this year on, we report the total land under forest management as forest land, and this area is reported in the land-usage matrix. The total area of all forest sub compartments (i.e. the potentially stocked area) amounted to 1,930.4 thousand ha. The area actually covered by trees (i.e. the actually stocked area), which appears in several official Hungarian statistics, amounted to 1,840.2 thousand ha. This area is calculated from that of the forest sub compartments by adjusting for gaps and overlaps in the canopy closure. Both in the graphs in this report, as well as in the CRF tables, the total forest area is reported, however, the carbon stock changes actually take place in the forest compartments, thus, the implied emission factor and m^3/ha data reflect the area of forest sub compartments.

Table 7.3 *The area of forest land, forest compartments and stocked land (ha).*

Reporting year	Total forest area (forest subcompartments and other)	Area of forest subcompartments	Calculatad area covered by trees
1984	1,741,288	1,630,720	1,493,135
1985	1,755,640	1,643,276	1,505,764
1986	1,765,833	1,650,576	1,513,582
1987	1,776,691	1,659,381	1,526,395
1988	1,787,607	1,666,586	1,530,587
1989	1,801,435	1,665,551	1,551,138
1990	1,813,902	1,681,467	1,563,585
1991	1,825,404	1,694,546	1,570,750
1992	1,838,339	1,708,804	1,589,760
1993	1,846,338	1,713,763	1,599,669
1994	1,852,141	1,719,146	1,608,811
1995	1,861,421	1,727,223	1,616,716
1996	1,871,746	1,737,818	1,627,588
1997	1,883,569	1,748,358	1,642,288
1998	1,893,962	1,758,645	1,656,399
1999	1,907,512	1,773,247	1,657,827
2000	1,921,170	1,787,372	1,689,401
2001	1,936,944	1,803,922	1,697,940
2002	1,955,180	1,823,377	1,723,805
2003	1,967,573	1,836,429	1,749,246
2004	1,980,902	1,850,809	1,769,988

2005	1,983,280	1,853,183	1,789,648
2006	1,998,472	1,869,349	1,805,801
2007	2,019,194	1,890,866	1,825,953
2008	2,030,830	1,903,360	1,840,171

Of all the forests, more than 700 thousand ha were established since 1930. After periods of slow increase of forest area, afforestations have been recently intensified (Figure 7.3.) Forest management has also a long history in the country, and most forests are more or less intensively managed. Finally, there are no unmanaged forests in the country: the forests where no forestry operations have taken place for about two decades to a century, and which are called forest reserves, only occupy a few thousand ha, i.e. 0.5% of all forests. Therefore, all reported forests of Hungary are considered as managed.

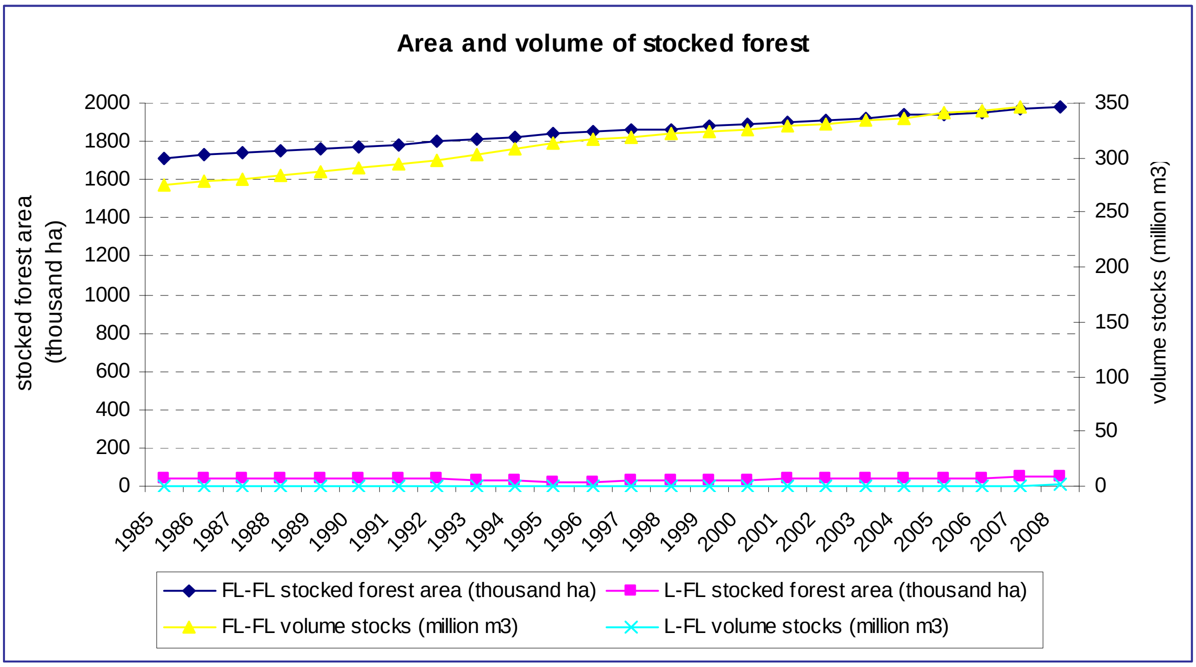


Figure 7.3 *Area and volume of stocked forest on land remaining forest land (FL-FL) and in the transition category land converted to forest land (L-FL). Note that the values of L-FL are rahter small, but not zero.*

Forest management planning, as well as forest inspection are quite intensive in the country. In addition, there is a *continuous forest inventory* in the country. The units of the planning (the so called sub compartments, which are also referred to here as stands), as well as the inventory are stands of about four ha of size on average. During planning, practically all *forest stands are surveyed once in every 10 years*, which makes it possible to track the fate of all stands, and thus that of all forest land. The survey produces detailed maps (analog maps from the late 1970s and digital ones based on GIS-interpretation since 2005), as well as a detailed description of the forest stands (e.g. species, mean breast height diameter, mean height, stock volume, number of trees, basal area, crown closure, volume increment etc.).
Due to the intensive forest monitoring as described above, *all forest stands are continuously accounted for*. This also means that 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, and there have not been any major deforestations for decades (their total annual area being around five hundred ha), no separate and detailed

statistics for conversions from forest to other land use were recorded until recently. Nevertheless, the forest inventory statistics include, and always included, all losses of volume stocks due to all deforestations. *Carbon stock changes due to deforestations are not reported separately in this inventory, however, they will be reported in our submission under the Kyoto Protocol.*
Until 2008 we did not identify the deforestations (D) individually. For annual statistical reports, the Forest Directorates (i.e. units of the forest authority) estimated and reported the annual amount of deforestations. On an area basis, it is rather small, since the area of deforestations has been some 500ha/year on average in the last decades, which is about 0.03% of the forest area), and about 5% of the average rate of afforestation, which amounts to some 10,000 ha annually. The reason for these area dynamics is that the Hungarian Forest Law is really rather rigorous and it is also rather strictly implemented with respect to the deforestations. Forest owners are obligated to cover the costs of a new afforestation of the same area to offset the deforestation.
In 2008 we introduced a new method in the National Forest Database (called „D-logs") to mark the conversion of each forest sub compartment and to classify them as deforestation.

***Table** 7.4.* The area of deforestations as reported earlier by the Forest Directorates (undigitized) and as developed from the so called D-logs. The area has been slightly increasing because of intensive highway building of the last few years.

Year	Deforestations reported by Foresrty Directorates	Deforestrations by the D-logs:
2003	347	
2004	642	
2005	196	
2006	256	
2007	880	
2008		294

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

"Forest" (the area actually or potentially covered by trees) 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. On the other hand, „forest land" includes both forests, as well as roads and other areas that are under forest management, but that are not covered by trees (see Table 7.3).

"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 3-15 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 Forest 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).

7.2.1. Forest Land remaining Forest Land (CRF sector 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.
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) until 2007 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”.

Category description

Estimated main characteristics of the category can be found in Table 7.7.

Table 7.5 *Emissions and removals in the sub-category by gas and inventory year*

Inventory year	Area (ha)	CO_2 (Gg)	CH_4 (Gg)	CO (Gg)	N_2O (Gg)	NO_x (Gg)
1985	1,715,260	-1,368	1.17	10.20	0.0080	0.29
1986	1,727,263	-3,502	1.18	10.33	0.0081	0.29
1987	1,737,913	-3,898	1.14	9.95	0.0078	0.28
1988	1,747,732	-4,131	1.10	9.65	0.0076	0.27
1989	1,760,872	-2,872	1.10	9.63	0.0076	0.27
1990	1,774,548	-3,437	1.02	8.89	0.0070	0.25
1991	1,785,815	-3,746	0.99	8.66	0.0068	0.25
1992	1,800,111	-4,497	0.91	7.93	0.0062	0.23
1993	1,814,240	-6,157	0.80	7.00	0.0055	0.20
1994	1,824,982	-6,705	0.82	7.16	0.0056	0.20
1995	1,836,869	-6,708	0.85	7.48	0.0059	0.21
1996	1,847,447	-2,798	0.93	8.13	0.0064	0.23
1997	1,857,227	-2,916	0.95	8.28	0.0065	0.24
1998	1,865,328	-3,902	0.92	8.07	0.0063	0.23
1999	1,876,618	-2,266	0.97	8.46	0.0066	0.24
2000	1,889,854	-1,222	1.03	9.05	0.0071	0.26
2001	1,900,546	-2,663	0.99	8.64	0.0068	0.25
2002	1,912,927	-2,121	0.99	8.70	0.0068	0.25
2003	1,923,327	-3,896	1.01	8.80	0.0069	0.25
2004	1,936,722	-2,878	1.01	8.83	0.0069	0.25
2005	1,940,331	-5,034	1.04	9.06	0.0071	0.26
2006	1,953,956	-3,056	1.01	8.84	0.0069	0.25
2007	1,968,840	-3,335	0.95	8.33	0.0065	0.24
2008	1,978,854	-4,886	1.01	8.80	0.0069	0.25

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, IPCC 2006 Guidelines*). 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 quantified, however, due to lack of data, only 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. 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 Forest 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. most types of bias, are considerably reduced when consecutive growing stock values are deducted to obtain stock changes. We note, however, that since growing stocks and their changes incorporate the effects of all processes mentioned above, 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 of the biomass carbon pools:

$\Delta C_B = (C_{t2} - C_{t1}) / (t_2 - t_1)$ 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 $biomass^{-1}$)
t_1 and t_2 = two consecutive years.

The application of these equations is possible because, as it was mentioned above, the forest inventory is continuous to enable the preparation of forest management plans. This can be achieved by surveying individual stands of about 4 ha of average size. Each stand is identified on management plans, and the inventory data is stored in a computerized database, i.e. the National Forest Database.

Each stand is surveyed once in every 10 years. During the survey, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. The survey includes mapping of the forest area, and is conducted by the stuff of the Central Agricultural Office Forestry Directorate, which is about 300-400 forest engineers strong. The survey methods applied in individual stands depend on species, age and site. 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, volume carbon stocks are available for each inventory year.

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, a new set of data is introduced in this report. The current values, that replace “previous” oven-dry density values and are used across all reporting years (Table 7.6), are much detailed by species than before, and are basic wood densities based on a thorough revision of previous data reported in literature, with some re-measurements for some species (Somogyi, Z. 2008. A hazai erdők üvegház hatású gáz leltára az IPCC módszertana szerint. Erdészeti Kutatások 92:145-162.)

Table 7.6 *Wood density values for the main species and species groups in Hungary as used in previous submissions (“previous” values) and as used in this and subsequent submissions (“current” values). (The source of the “previous”, i.e., previously used 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. New densities were reported by Somogyi, Z. 2008. A hazai erdők üvegház hatású gáz leltára az IPCC módszertana szerint. Erdészeti Kutatások* ***2007-2008. Vol. 92. 154****. In Hungarian.*

Species or species group	Previous density (t/m^3)	Current density (t/m^3)
Quercus robur	0.665	0.57
Quercus pertaea	0.665	0.61
Other quercus	0.665	0.55
Quercus cerris	0.77	0.64
Fagus silvatica	0.68	0.59
Carpinus betulus	0.79	0.58
Robinia pseudoacacia	0.74	0.59
Acer sp.	0.5925	0.52
Ulmus sp.	0.5925	0.58
Fraxinus sp.	0.5925	0.56
Other hard broadleaves	0.5925	0.50
Hybrid poplars	0.37	0.34
Indigenous poplars	0.395	0.36
Salix sp.	0.33	0.36
Alnus sp.	0.56	0.43
Tilia sp.	0.56	0.48
Other soft broadleaves	0.56	0.48
Pinus silvestris	0.53	0.42
Pinus nigra	0.53	0.47
Picea abies	0.53	0.39
Larix decidua	0.53	0.49
Other conifers	0.53	0.37

Note that no biomass *expansion* factor is applied for the above-ground biomass, because all wood volume (m^3) values in Hungary are estimated, and expressed, as total volume of trees above ground 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 (above-ground) volume to above ground biomass, expansion is therefore not necessary, and only conversion is done to estimate biomass. 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 nevertheless slight bias.

With respect to the below-ground biomass, a general root-to-shoot ratio (R) is applied. Until a few years ago, carbon stock changes in the below-ground biomass carbon pool were not accounted for. Since 2006, below-ground biomass carbon stock changes have also been reported, however, 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 171 m^3 ha^{-1} (in 1990) and 185 m^3 ha^{-1} (in 2008), corresponding to an average aboveground biomass of 95 t ha^{-1} (in 1990) and 100 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. 0.48 and 0.51 tonnes C tonnes $biomass^{-1}$ is used for broadleaves and coniferous respectively.

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

In Hungary, data has not been collected systematically even in the main ecosystem types for dead wood, litter or soil. However, it seems justified to state that these pools continue to sequester carbon in the medium-term, rather than to lose carbon.
To demonstrate, that DOM is not emitter, we can present the results published in IPC-Forest, Forest Focus and Life+ programs on forest health (based on systematic sampling) showing the expectable constant accumulation of biomass of standing dead trees.

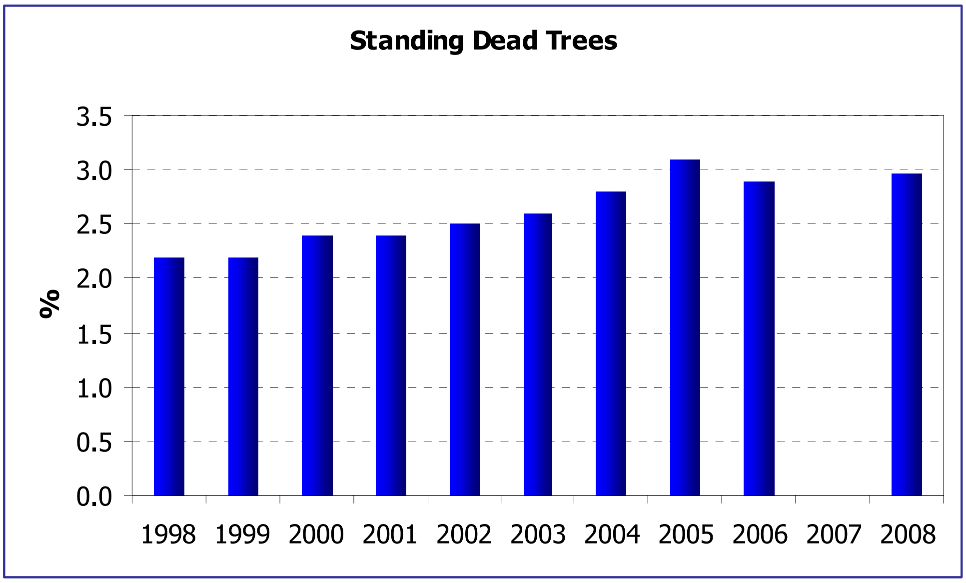


***Figure** 7.4 The amount of standing dead trees in Hungarian Forest (number of trees in the sample, %). Data source: IPC-Forest, Forest Focus and Life+ program). Note that no survey took place in 2007.*

The slow but steady increase of the amount of standing dead trees, and in general of the dead organic matter in the Hungarian forests, is mainly due to two reasons. One is the increased sustainability of managing existing forests, which means that less wood is harvested than what is grown. This effect can easily be seen from Figure 7.4, too, which shows the amount of estimated current annual increment and harvest statistics. The difference of increment and harvests is large enough to claim sustained yield, which is also obvious from the growing trend of total volume stocks for the last two decades.
From the increase of the growing stock of Hungarian forests, we can safely assume that the amount of deadwood increased, too. The relationship is not linear, of course. In the last decades, the close-to-nature forest management has been favoured and came to the front,

and clearcuts were restricted, so we can suppose the accumulation of both deadwood and litter in the Hungarian forests (which in turn also increases 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://afoludata.jrc.it/events/Kyoto_technical_workshop/presentations/Z_Somogyi.pdf.)

The other reason of the increase of the dead organic matter in the forests is that about one-third of all forests are afforestations since 1930, and most of these forests are still in their intensive growing phase which means that the dead organic matter pools have not yet saturated.
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 in this pool due to the fact that the amounts of carbon entering this pool (wood products from harvests) and exiting it (products ending their life) are about the same.

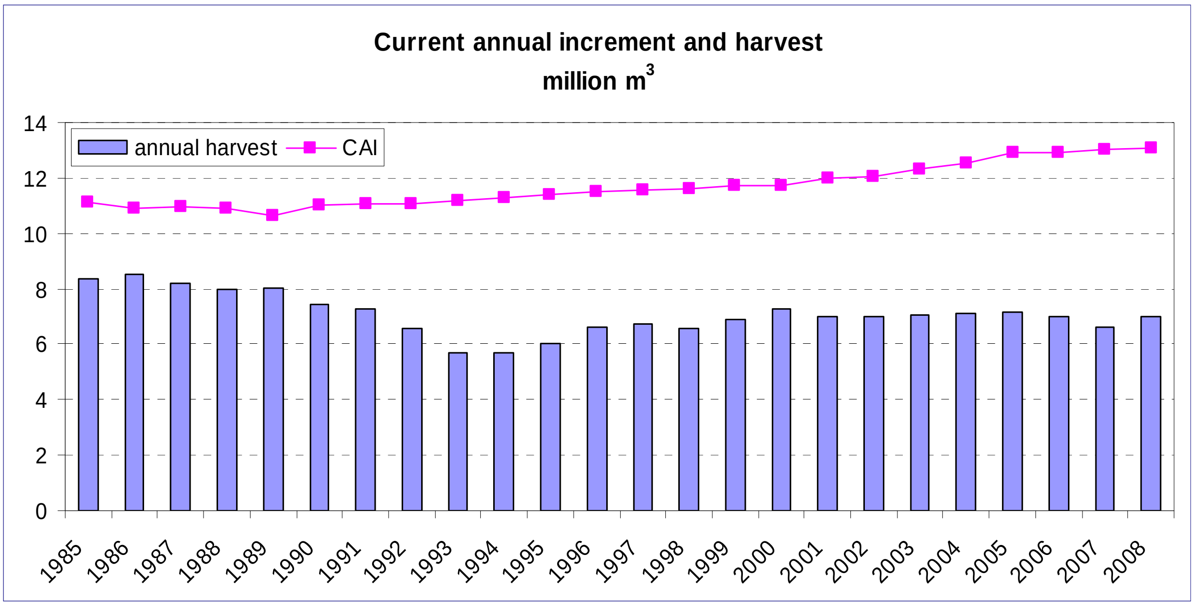


Figure 7.5 *Current annual increment and annual harvest in Hungary in the last decades. Data source: National Forest Database.*

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 Cropland subcategory.

Methodological issues – non-CO_2 emissions
Estimated non-CO_2 emissions originate from burning of slash on-site and, for the last couple of years, wildfires. Non-CO_2 emissions from sources are not significant, and are only reported for the sake of completeness and that of time series consistency with previous years. Note that CO_2 emissions from these sources are accounted for in the biomass pool, because we apply the stock-change method. Theoretically, thee emissions include carbon of CO and CH_4. However, these gases are nevertheless 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 the latest IPCC (2006) guidelines on reporting.

The estimation methodology of slash-burning is based on the method suggested by the *IPCC 1996 Guidelines*, as well as equation 3.2.19 of the *GPG for LULUCF (IPCC, 2003)*. 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, see Table 7.7 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 oxidized on site (0.9). Finally, the 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 are 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.

Wildfires are very erratic but not so significant phenomenon in Hungary. Beginning 1999, the Fire Department has provided data only on the number and area of forest wildfires, however, until 2006, these numbers are not deemed accurate, and the emissions based on these are only rough ones.

In 2006, Hungary joined to the European Forest Fire Information System (EFFIS, http://effis.jrc.it or http://www.jrc.cec.eu.int/), and a new database was established in the Twinning Project No. HU 2004/016-689.01.02. Thus, beginning 2007, the Fire Department locates the fires, surveys the affected area, and, subsequently, the Forest Authority identifies on site the affected forest sub compartments. The Forest Authority also collects data on how much percent of the growing stock of each forest sub compartment was burnt in the fire. (Only crown fires affect the biomass accounted in the GHG inventory, the surface- and ground fires only affect some of the understory vegetation, which is not reported anyway.) In this way, the activity data is double-checked, and the emissions can be accurately calculated based on the growing stock. The calculation applies the same factors as above, i.e., the fraction oxidized, carbon fraction of harvested wood, emission ratios by gas, N/C ratio, and molecular weight.

In the lack of other data, the amount of growing stock burnt in wildfires between 1999-2006 are calculated by the ratio of fire-affected area and the burned growing stock per unit area of wildfires of 2007-2008.

With the exclusion of some areas affected by forest fires that are subsequently considered as Deforestation (D), these areas remain under forest management by the law, and the Forest Authority prescribes and inspects the reforestation of these areas.

Table 7.7 *The amount of controlled burning and forest fires based on all available data.*

Reporting year	Harvested volume (m^3)	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m^3)
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	229	756	3,000
2000	7,287,456	883,913	811	1,595	80,000
2001	7,010,979	843,752	419	1,223	57,000
2002	7,013,167	850,311	382	1,226	57,000
2003	7,053,960	857,268	375	1,054	49,000
2004	7,094,753	864,225	104	354	2,000
2005	7,167,426	885,614	150	3,530	170,000
2006	7,005,190	863,594	97	625	3,000
2007	6,609,099	812,238	284	3,471	160,660
2008	7,024,025	719,891	175	731	2,730

7.2.2. Land converted to Forest Land (CRF sector 5.A.2)

Category description

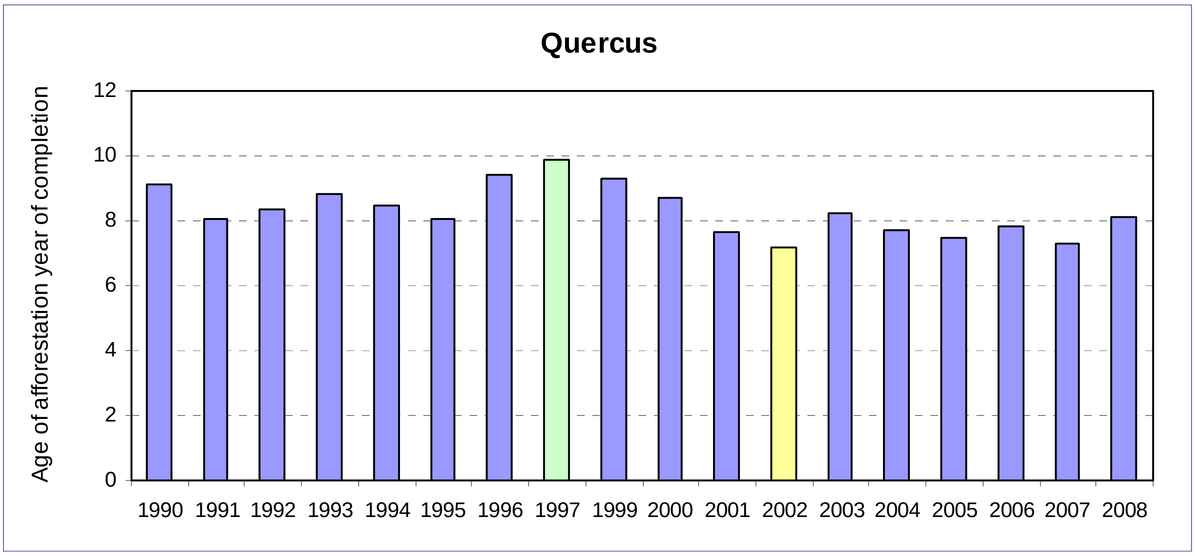
Carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) are reported in this category. As this sector represents a very minor contribution to greenhouse gas emissions and removals, only carbon stock changes in the biomass pools are accounted for.

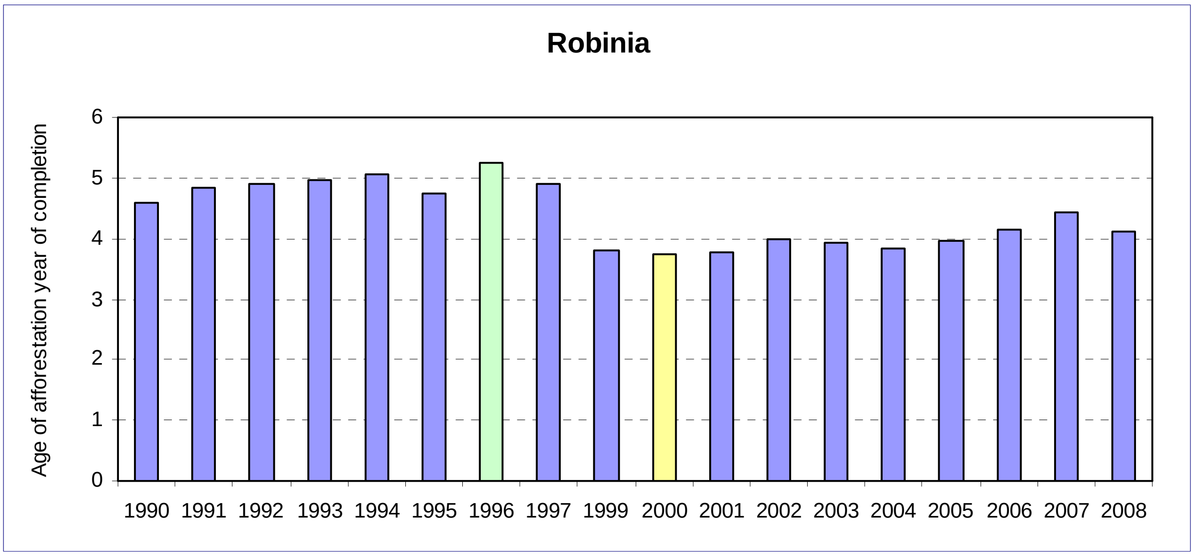
(We note here that, according to recent estimates, converting land from croplands does not entail any emissions from soil. (See Somogyi, 2005: Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects. Results of the monitoring case study in the test site in Hungary. CarboInvent, WP8.5 report, http://www.joanneum.at/carboinvent/D_8_5.pdf, and 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. Kohlenstoff-Akkumulation im Boden nach

Neuaufforstungen: Beitrag zur Reduzierung der C-Emission in Ungarn? (C-accumulation in the soil after afforestation: contribution to C-mitigation in Hungary?) Forstarchiv v. 77(2) p. 63-68. However, because most of the huge amount marginal lands are former croplands, 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.)

The estimated area of, and CO_2 emissions from this category are summarized in Table 7.8 below.
Note that this category contains forests under afforestation until they are regarded as “forest land” in the National Forest Database. 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 8 years for slow growing species, 4-5 years for the faster growing Black Locust (Robinia pseudoacacia), and even less for poplars. The ratio of the various species in the afforestations in any given year of course keeps fluctuating over time.





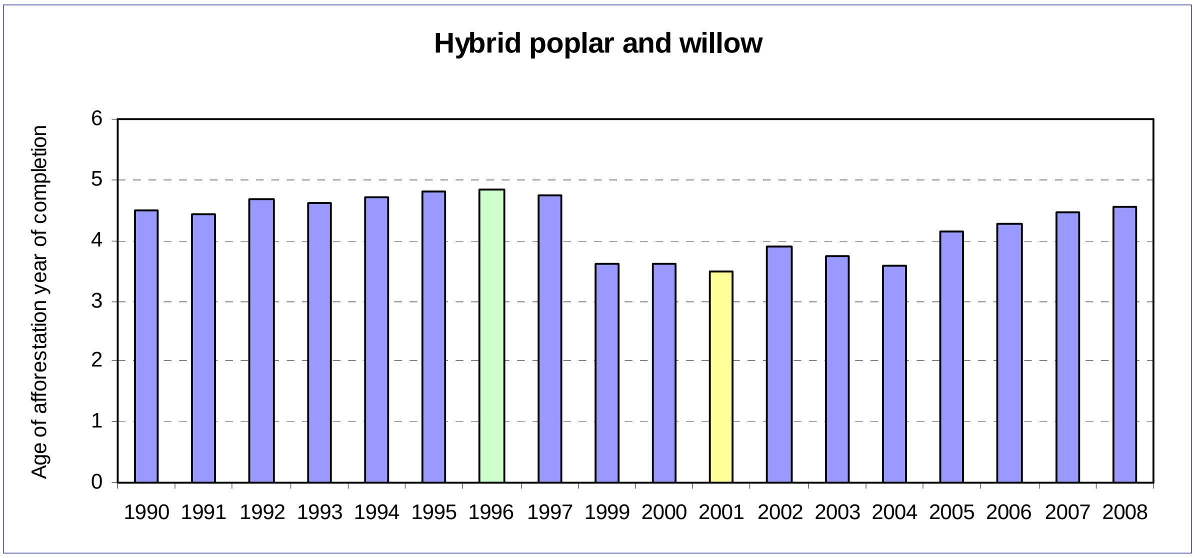


***Figure 7.6** Average age of Quercus, Robinia, and Poplar and Willow afforestations in the year of completition (for explanation, see text).*

Hungary has a long, very successful and internationally recognized tradition of afforestation. About the 30% of the current forests were planted since 1930. The afforestation efforts are still continuous, and decisively subsidy-driven. The subsidies are granted to each forest-sub compartment in three steps: (1) at initial planting, (2) in the second year, (3) in the year when the afforestation is deemed completed. The forest sub compartments under afforestation are annually surveyed on site by the National Forest Authority, and the 3rd portion of the subsidy is only granted, if the juvenile stand is in good condition and has overwhelmed the competing herbs and shrubs. This is the time when the Forest Authority declares the area as forest, and we account for this area in the FL area. However, this year differs by species and also by stand. The between-stand variation is mainly due to site conditions, weather, the local forest manager's efforts etc. The afforestated stands are recorded in the National Forest Database annually and can be tracked annually. This method of administration is based on individually stand-surveys and has been very successfully applied to ensure the successful completion of the afforestations. However, as a consequence of this method, the category that includes land in the conversion phase always includes areas of various species that have just been afforested (0-1 year), that have been tended (1-few years), and that are just before the formal moving of these areas to the FL-FL category (i.e., stands of several years, depending on species, awaiting for being “completed”).

In this submission, the emissions and removals of L-FL were completely remodeled based on the official annual reports between 1989 and 2008 of the Central Agricultural Office Forestry Directorate. These reports contain area- and species composition data of the afforestations in 3 distinct categories: (1) the afforestations in the year of initial planting, (2) afforestations „under construction”, between category 1 and 3, and (3) afforestations in the year of completing (actually transforming them into FL-FL). The growing stock of the L-FL area is registered in the NFD, and is estimated by a specific, although simplified, yield model.

Table 7.8 *The area, as well as CO_2 emissions and removals on land converted to forest*

Inventory year	Area (ha)	CO_2 (Gg)
1985	40,380	21
1986	38,570	45
1987	38,778	9
1988	39,875	-7
1989	40,563	-3
1990	39,354	24
1991	39,589	-29
1992	38,228	-7
1993	32,098	66
1994	27,159	90
1995	24,552	48
1996	24,299	38
1997	26,342	11
1998	28,634	6
1999	30,894	7
2000	31,316	13
2001	36,398	-51
2002	42,253	-65
2003	44,246	-53
2004	44,180	-58
2005	42,949	-71
2006	44,516	-49
2007	50,354	-99
2008	51, 975	-106

Methodological issues – CO_2 emissions and removals

Concerning biomass, 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 inherent nature of the stock change method, because different lands move into and out from this category, and because the time that the various land areas are accounted for in this category significantly varies by species and site, the reported carbon stock changes are not due to, and cannot be interpreted as only driven by natural processes like tree growth etc., rather, they are mostly artifacts as far as annual values are concerned. Therefore, implied emission factors and other indices, which are in other cases useful for error checking or verification, cannot be interpreted for any single year, rather, only statistics for longer periods can be regarded as meaningful.
With respect to deadwood and litter, the assumption is made that the stock change is zero. This is a justified assumption, because both the litter and deadwood pools are zero before the conversion, and usually increase after the conversion.
It is to be noted that soil carbon stock changes due to conversion of land to forest land are indirectly estimated and reported in section 7.3.2 where total carbon stock changes due to all land conversions are simultaneously covered for all land categories.

7.2.3. Category-specific 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. We note here that uncertainties were assessed for the first time for the 2000 inventory. In 2003, Hungary applied quantitative sensitivity analysis to her LULUCF GHG balance, based on expert judgment.
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 conservative estimation, i.e. overestimation of net emissions.
With respect to accuracy, the estimated values are generally 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. We note that accuracy was improved e.g. by introducing new, more realistic, country-specific based wood density values. 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.
The system of calculating 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 the bulk of all emissions and removals are. 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. However, a more detailed uncertainty analysis of the activity data (area and volume of forests) cannot be performed as the current forest inventory system has not been designed to yield uncertainty information.
Finally, it can be concluded that many sources of error have been removed earlier 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 previous estimates.

7.2.4. Category-specific QA/QC and verification

Almost all calculations are based on the activity data taken from the National Forest Database. This database is the most accurate database in the country on the forests. The first complete and country-wide inventory was accomplished in 1976 and has been applying computer-based informatics since the early ’80-s. The database is updated annually, field data is collected by the stuff of the Central Agricultural Office Forestry Directorate (involving 300-400 forest-engineers), 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.
This year the GHG is completed by the CAO Forestry Directorate (formal National Forest Service), that runs the National Forest Database.
Apart from double-checking of the data processing and correct application of IPCC assumptions and methodologies, QA/QC was performed at the national level by the Hungarian Forest Research Institute. The separation of the two roles (i.e., to prepare and to check the GHG inventory) has also improved on data quality.
However, data verification was, and is continuously, conducted concerning activity data (see the comparison of volume stock changes with trends of wood volume increment and harvest, see also previous NIRs of Hungary). The applicability of background data and correctness of the arithmetics used were 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.

7.2.5. Category-specific recalculations

Recalculation took place this year because of the new dataset on L-FL, the new forest fires ativity data and the new country specific wood densities and carbon fractions of the latest IPCC 2006 Guidelines.

7.2.6. Category-specific 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 for the Kyoto reporting to improve documentation.
In 2008 a new method was designed and introduced into the National Forest Database to identify the deforested areas. The operation of this data collection in the introductory year will be revised later, however, the current submission is based on this data, and after the first year, we have a chance to improve data quality.
There are plans to collect data on some DOM pools (i.e., litter and lying deadwood based on a systematic sampling grid of 4×4 km, used in ICP Forest, Forest Focus and Life+ programs. Over a thousand plots will be surveyed in 2010.

7.3. CROPLAND (CRF sector 5.B)

7.3.1. Description of category

Though a significant decrease of the area of croplands was characteristic for the last four decades - roughly 800,000 hectares were abandoned or transferred to another category of land use – cropland still represents the main land use category in Hungary with its 51% proportion from the total territory of the country (Figure 7.2). All the plough-lands with annual crops and the orchards and vineyards with perennial woody crops and kitchen gardens are classified here. The emissions/removals from set-asides are reported under 5.F Other Land category. (Chapter 7.7)
The area of Cropland category is based on HCSO annual land-use statistics, revised by the HCSO's and the inventory agency's experts to account for inconsistencies.
The CO_2 removal of living (woody) biomass and emissions from cultivated mineral soils and agricultural lime application are reported under this category. (Organic soils are not under cultivation in Hungary.) The emission from Cropland was 263.41 Gg in 2008. The trend of the emissions is fluctuating.

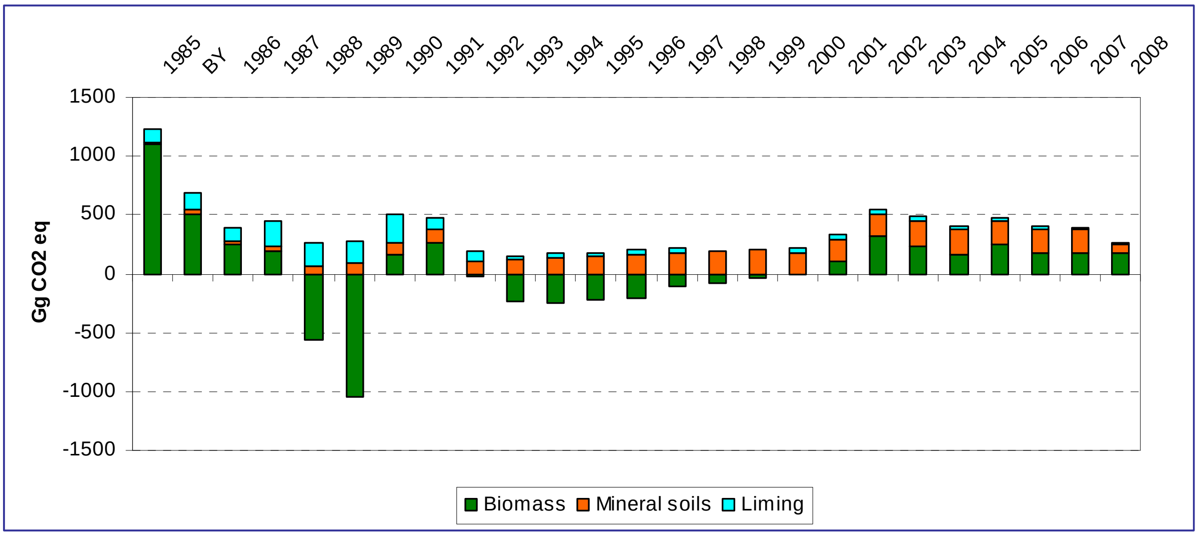


Figure 7.7 *Emissions/Removals from 5.B Cropland category 1985-2008*

7.3.2. Methodological issues

Cropland remaining cropland

<u>*Carbon stock change in living biomass*</u>

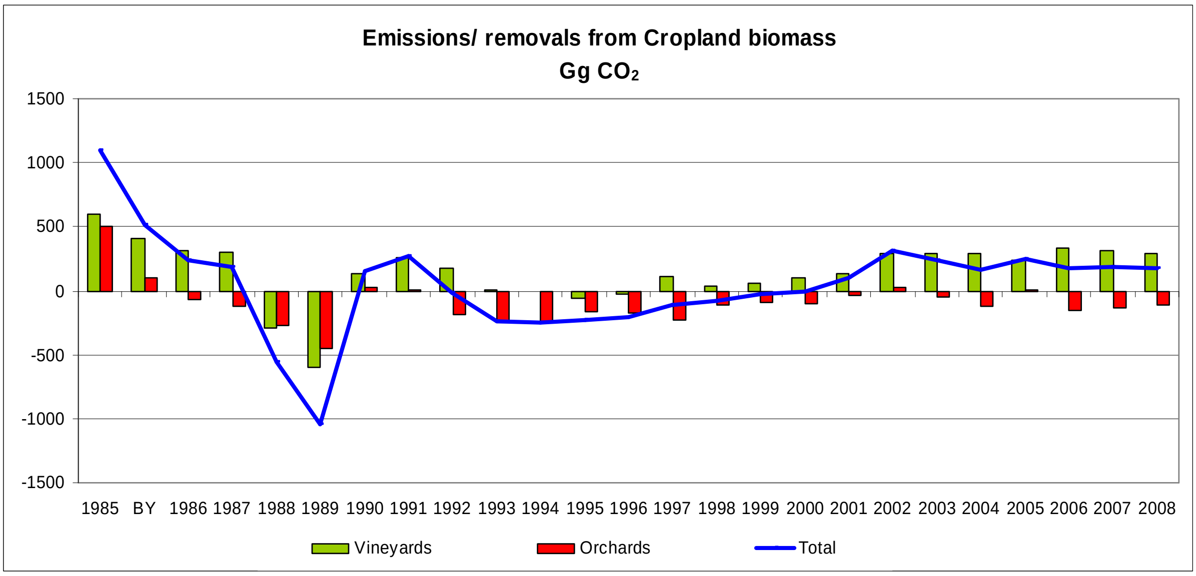


Figure 7.8 *Trends in emissions/removals from Cropland living biomass 1985-2008*

In 2008 Cropland living (woody) biomass was a source of 171.75 Gg CO_2 in Hungary, due to vineyard removals. There is a permanent vineyard abandonment system in the EU, therefore vineyard removal is subsidized in Hungary similarly to other EU member states. Orchards were a sink of 31,236.87 tonnes carbon in 2008, although the total area of orchard decreased slightly in 2008.

The trend in emission from Cropland woody biomass is changeable over the time series as shown in Figure 7.5.

Choice of method

Carbon stored in the biomass of croplands was calculated taking the perennial woody vegetation (in Hungary including orchards and vineyards) into consideration. The carbon stock change in cropland biomass (ΔCC_{LB}) was estimated from the annual rates of biomass gain and loss provided by the Tier 1 GPG for LULUCF (IPCC, 2003) method. Similar to the Equation 3.2.2 of the GPG for LULUCF (IPCC, 2003) the following formulas were applied:

$$\Delta CC_{LB} = \Delta C_G - \Delta C_L$$

Where:
ΔCC_{LB}=annual change in carbon stocks in living biomass on Cropland
ΔC_G= annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1}
ΔC_L= annual decrease in carbon stocks due to biomass loss, tonnes C yr^{-1}

$$\Delta C_G = A_G \cdot G$$

$$\Delta C_L = A_L \cdot L$$

Where:
A_G= area of perennial woody cropland (orchard and vineyard in Hungary)
G= IPCC default value for perennial crops carbon accumulation rate is 2.1 t C ha^{-1} yr^{-1}
A_L= area of cropland on which perennial woody crops (orchard and vineyard) are removed
L= IPCC default value for perennial crops carbon loss 63 t C ha^{-1} yr^{-1}

Choice of activity data

Activity data to estimate land areas (A_G, A_L) of growing stock and removals in perennial

woody crops are derived from the statistics of HCSO. The HCSO records the orchard and vineyards are by legal forms (private farms and agricultural enterprises), but removals are reported only for agricultural enterprises. Therefore a process was elaborated to estimate the missing removal statistic for private farms which is shown in Annex 3. The methodology for the estimation of the missing activity data is considered to provide a relatively conservative approach to the calculation of emissions and removals.

Uncertainty assessment

Uncertainty of HCSO's Vineyard and Orchard area data for the period from 2002 to 2005 is 5.8 percent and 6.1 percent respectively. (Uncertainty assessments for area data for other periods are not available.) The default uncertainty level of biomass stock factors is ±75% according to Tier 1 method.

Carbon stock change in soils

To estimate the change of carbon stock in soils, the change of the view in soil cultivation has to be taken into consideration. As soil - besides the climate and weather - is one of the main factors of production, which basically determines the quality and economical conditions of production, the knowledge of the effects of plant production on soil is very important. Among the land use practices the soil cultivation has the most radical effects on soil properties. The need for environmental friendly and energy saving soil tillage systems is increasing as the consequences of improper soil cultivation practice that characterized the last decades are manifested in unfavourable soil properties (Birkás, 2002, Birkás et al., 2007). In accordance with the combat against the damages (soil degradation) due to the improper soil use, the conventional soil cultivation methods are prospectively replaced by conservation tillage, including different versions of reduced till, mulch-till, crop residue management etc. (Forgács et al., 2005, Zsembeli, 2001). These new soil tillage methods aim the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter, hence affect soil C stocks in croplands considerably. All over the world several soil cultivation methods were studied in order to investigate their effects on the soil state and properties including the water balance and C-cycle. Though In Hungary there are no extensive measured data yet, some results have been already achieved concerning the effect of reduced tillage systems on the CO_2-emission from the soil providing several valuable information in the respect of soil utilization (Gyuricza et al., 2005; Tóth and Koós, 2006; Zsembeli et al, 2005, 2006; Zsembeli and Kovács, 2007).

Mineral soils

Choice of method

For the calculation the IPCC Tier 1 method, equation 3.3.3. (IPCC, 2003) was used as follows:

$\Delta C=(SOC_0-SOC_{0-T})*A/T$

$SOC=SOC_{ref}*F_{LU}*F_{MG}*F_I$

Where :

ΔC=annual change in carbon stock in mineral soils

SOC_0= *average* soil organic carbon stock in the inventory year for current land use

SOC_{0-T}= *average* soil organic carbon stock in the inventory year for former land use

A= area converted for a former land use

T= transition period (default 20 years was applied)

SOC_{ref}= the reference soil carbon stock

F_{LU}= stock change factor for land use or land-use change type

F_{MG}= stock change factor for management regime

F_I= stock change factor for input

In Hungary the soil organic carbon stock can be estimated aggregately for the different land-use types, therefore the annual carbon stocks were used for the calculation.
The categorization of croplands is partly based on expert judgement due to the lack of sufficient statistics mainly about the management and input of the recent Hungarian land use practice. Nevertheless the input factors can be judged well on the base of the actual composition of annual crops, while the change in the management practice can be followed by knowing the number of the tools and machines that are used in reduced tillage. The methodology of these judgements is detailed in the *Choice of activity data* paragraph below.

Choice of activity data

In order to gain relevant activity data, the area of croplands was stratified by soil type, climate, management and input. For the identification of the spatial extension and distribution of each sub-category the area data from the HCSO were harmonized with the data originating from the CORINE Land Cover Database reference to 2000.

Soil type

The soil types were determined on the base of AGROTOPO (digital soil map of Hungary) data base and were harmonized with the land use types of CLC to determine the rate of land use types on different soil types (GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences). The Hungarian national soil classification system classifies soils by genetic types, and these types are not comparable with the types identified by the WRB or the USDA systems. Therefore there was a project, titled "Modernization and international correspondence of Hungarian soil classification", founded by the Hungarian Scientific Research Fund, managed by Erika Michéli. This study was the base of the classification of the soils of Hungary into the soil type groups needed for the calculations. As a result of the classification the croplands in Hungary occupied four soil types from among the types that are determined in the *GPG for LULUCF (IPCC, 2003)* with following proportions of the total land in 2008 (Table 7.9).

***Table 7.9** Classification of the croplands in Hungary by soil type in proportion to the total land in 2008*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	77.22
Low Activity Clay Mineral	2.16
Sandy	5.17
Aquic	15.45

As the proportions show, high activity clay mineral soils are dominant. Among the soils utilised as croplands chernozems, brown forest soils represent this group. Salt affected soils, which are also characteristic to Hungary, also belong to this group, but they are also used as grasslands, mainly depending on the extent of salinization.

Climate

The climatic classing, the determination of the spatial distribution of climate zones was made by the Hungarian Meteorological Service. Two categories were determined: namely Cold Temperate Dry (CTED), where the mean annual temperature (MAT) is just below 10℃ and the annual precipitation is less than the evapotranspiration, and Warm Temperate Dry (WTED), where the mean annual temperature (MAT) is above 10℃ and the annual precipitation is less than the evapotranspiration. After determining the climate zones, they were harmonised with the soil classing: the four soil types were classed into the two climate categories (made by the GIS Lab of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences) according to their spatial distribution in Hungary. As a result, the proportions indicated in the following table were gained (Table

7.10)

***Table 7.10** Classification of the croplands in Hungary by climate in proportion to the total land in 2008*

Soil Type Category	Proportions by Climate Category (%)	
	Cold Temperate Dry	Warm Temperate Dry
High Activity Clay Mineral	40.3	59.7
Low Activity Clay Mineral	55.7	44.3
Sandy	45.4	54.6
Aquic	39.6	60.4

Management

In Hungary full tillage of croplands was the only applied cultivation system until the end of 1990ies and it is still dominant, though the area cultivated with reduced tillage methods is increasing year by year. From 1998 in accordance with the combat against drought damages and soil degradation, conventional soil cultivation was prospectively replaced by conservation tillage methods, among them mainly which aims the decrease of the depth of the regularly cultivated soil layer and the formation of a topsoil rich in organic matter. As the management of croplands considerably modifies soil C stocks, we estimated the area of the non-conventionally cultivated croplands. Among the main soil protective management practices that affect soil C stocks in croplands (e. g. residue management, reduced tillage, fertilizer management applying mineral fertilizers and organic amendments, irrigation management) reduced tillage is the most characteristic in Hungary recently. To account for changes in soil C stocks of croplands we estimated the areas of the two main cultivation types at the beginning and end of the inventory time period. There are no sufficient data available to estimate the correct actual area of reduced tillage hence the calculation is based on expert judgement. The principle of the calculation is that the total area of cereals (winter wheat, barley, maize) can be considered stable (approximately 2.6 million ha), the fluctuation is not considerable. The newly introduced soil protective cultivation methods are used mainly in the case of cereal production. We took the cumulative number of sold machines and tools that are suitable for reduced tillage into account since 1998 (source: KITE Ltd., the biggest company in agricultural service and commerce in Hungary), and calculated the extent of the area, where these machines and tools can be applied (one fourth of the actual area of cereals). According to our judgement, by the reported year of 2008, the area cultivated by applying one of these alternative methods was extended approximately to 226,100 hectares in Hungary.

Input

To choose the input factors (Table 7.11) that representing the agricultural practice in Hungary, the characteristics of crop rotations were taken into consideration. According to the *GPG for LULUCF (IPCC, 2003)*, the input factors represent the effect of changing carbon input to the soil, as a function of crop residue yield, bare-fallow frequency, cropping intensity, or applying amendments. Therefore the four soil types representing the Hungarian croplands were divided further into three input categories. As the residue management is getting to be the part of the full till practice in a wider and wider extent, the proportion of the area of medium input for full till was enlarged of 5 percent while the territory of low input was decreased down to 50 percent from 55 in 2008 compared to the previous years on the base of expert judgement. These changes in the area proportions resulted in a sharp, relatively high increase in the carbon stock change from 2007 to 2008, but we consider these values more realistic taking into account the new trends arose recently in the soil cultivation techniques in Hungary.

Table 7.11 *Classification of the croplands in Hungary by input in proportion to the total land in 2008*

Input category	Proportion of total cropland area (%)
Low	50
Medium	45
high with no manure	5

Low residue return is due to removal of residues, which is very characteristic to the growing technology of cereals (wheat, rye, barley) and a certain fraction of maize in Hungary. As the total are of cereals - except for maize - is approximately 1.4 million hectares, the proportion of the low input category is significant. We also have to take into consideration that crop residues are typically removed from a certain amount of the area of the crops listed under *medium* input.
Medium input cropping systems represent annual cropping with crops where crop residues are returned to the field. This way of growing is characteristic – besides some other less important crops - to maize, sunflower and sugar beet production. These three crops occupy approximately 1.8 million hectares annually. But as it was mentioned earlier, not the total area of these crops can be calculated in the *medium* input category.
High input (without manure) rotations are not widely used in Hungary, practically limited to the use of green manures and cover crops.

No area was taken into account belonging to the *high input (with manure)* category as regular addition of animal manure is not characteristic to the recent Hungarian agriculture.

Choice of stock change and emission/removal factors

Taking the recent practice of soil cultivation and crop production into consideration the categorisation of the croplands of Hungary has been made regarding the climate, soil type, management and input. Since extended country-specific stock change factors are not available in Hungary at the moment, the stock change factors were taken from the GPG for LULUCF (IPCC, 2003) Table 3.3.4. The stock change factors applied in the Hungarian inventory are shown in Table 7.12.

Table 7.12 *Categorization of croplands in Hungary by carbon stock and stock change factors*

sub-categories				SOC_{ref}	F_{LU}	F_{MG}	F_I
Climate	Soil	Management	Input				
cold dry	HAC	full till	low	50	0.82	1	0.9
cold dry	HAC	full till	medium	50	0.82	1	1.0
cold dry	HAC	full till	high with no manure	50	0.82	1	1.1
cold dry	HAC	reduced till	medium	50	0.82	1.03	1.0
warm dry	HAC	full till	low	38	0.82	1	0.9
warm dry	HAC	full till	medium	38	0.82	1	1.0
warm dry	HAC	full till	high with no manure	38	0.82	1	1.1
warm dry	HAC	reduced till	medium	38	0.82	1.03	1.0
cold dry	LAC	full till	low	33	0.82	1	0.9
cold dry	LAC	full till	medium	33	0.82	1	1.0
cold dry	LAC	full till	high with no manure	33	0.82	1	1.1
warm dry	LAC	full till	low	24	0.82	1	0.9

warm dry	LAC	full till	medium	24	0.82	1	1.0
warm dry	LAC	full till	high with no manure	24	0.82	1	1.1
cold dry	sandy	full till	low	34	0.82	1	0.9
cold dry	sandy	full till	medium	34	0.82	1	1.0
cold dry	sandy	full till	high with no manure	34	0.82	1	1.1
warm dry	sandy	full till	low	19	0.82	1	0.9
warm dry	sandy	full till	medium	19	0.82	1	1.0
warm dry	sandy	full till	high with no manure	19	0.82	1	1.1
cold dry	aquic	full till	low	87	0.82	1	0.9
cold dry	aquic	full till	medium	87	0.82	1	1.0
cold dry	aquic	full till	high with no manure	87	0.82	1	1.1
warm dry	aquic	full till	low	88	0.82	1	0.9
warm dry	aquic	full till	medium	88	0.82	1	1.0
warm dry	aquic	full till	high with no manure	88	0.82	1	1.1

Calculation of carbon stock change in soils

On the base of the methodology described above the areas, the relevant carbon stocks and their annual changes are reported for the sub-category Cropland remaining Cropland for the period of 1985-2008 in Table 7.13

Table 7.13 *Carbon stocks and their changes in the Cropland remaining Cropland*

Year	A (1000 ha)	SOC (Mg ha^{-1})		ΔC_{CC} (Gg yr^{-1})
		0-T	0	
1985	5280.92	38.18	38.18	0.00
BY	5272.45	38.18	38.18	0.00
1986	5272.43	38.18	38.18	0.00
1987	5264.01	38.18	38.18	0.00
1988	5254.88	38.18	38.18	0.00
1989	5246.55	38.18	38.18	0.00
1990	5240.03	38.18	38.18	0.00
1991	5190.65	38.18	38.18	0.00
1992	5141.27	38.18	38.18	0.00
1993	5083.82	38.18	38.18	0.00
1994	5026.38	38.18	38.18	0.00
1995	4968.93	38.18	38.18	0.00
1996	4911.49	38.18	38.18	0.00
1997	4854.04	38.18	38.18	0.00
1998	4796.60	38.18	38.19	1.71
1999	4739.15	38.18	38.19	2.69
2000	4681.71	38.18	38.24	12.83
2001	4672.10	38.18	38.24	13.80
2002	4662.49	38.18	38.24	14.76

2003	4652.88	38.18	38.25	15.73
2004	4643.26	38.18	38.25	16.69
2005	4650.03	38.18	38.26	17.70
2006	4645.50	38.18	38.26	18.68
2007	4644.08	38.18	38.27	19.66
2008	4642.66	38.18	38.38	45.84

Liming

Liming also shows a decreasing tendency in Hungary in the last decade (Figure 7.8). In order to calculate the application of carbonate containing lime (calcic limestone), or dolomite ($CaMg(CO_3)_2$) to agricultural soils as a source of CO_2 emissions we had to determine the amount of carbonate containing chemical amendments that was used for soil reclamation in the reporting year.

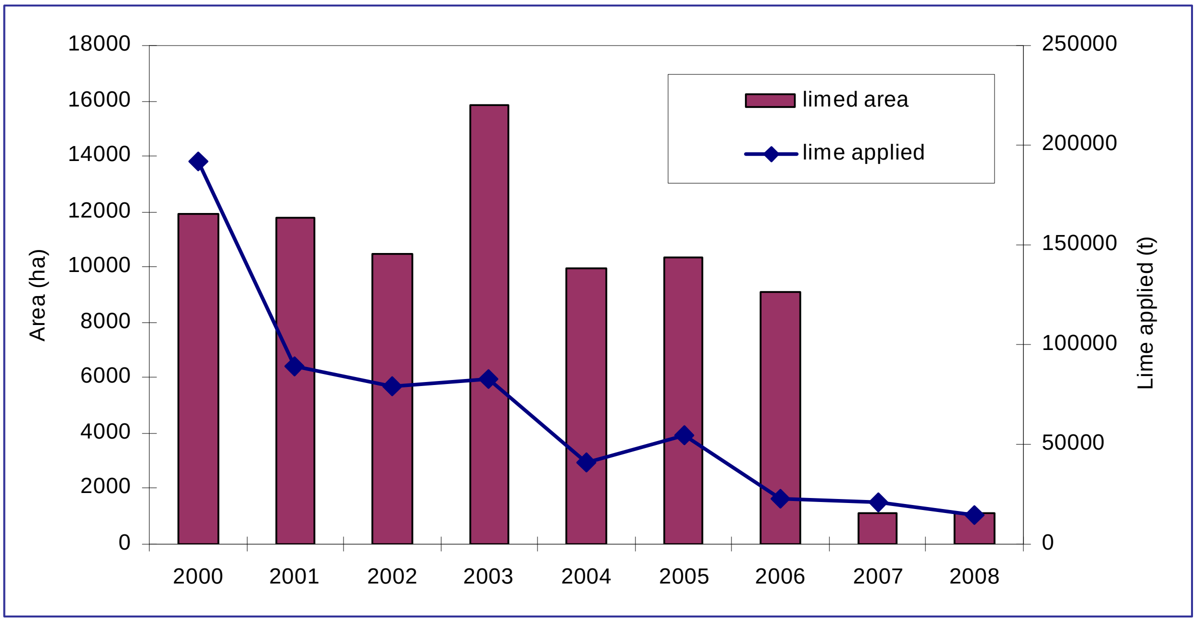


Figure 7.9 *The total area reclaimed by lime or dolomite and the amount of amendment applied in Hungary in the period of 2000- 2008 (lime fertilization is not included)*

The total area of the reclaimed soils was available from the statistical database of the Agricultural Economics Research Institute; (website: www.akii.hu) for the period of 2000-2006. Earlier data till 1999 can be found in the annual statistical pocket-books of the Hungarian Central Statistical Office. Nevertheless the consistency of the data is ensured, as both institutions used the same data sources (regular agricultural surveys that cover agricultural enterprises as well as private farmers). In the data bases the reclaimed soils include acidic, salt affected and sandy soil categories. The last category of sandy soils was not taken into account from the point of view CO_2 emissions, as high organic matter containing amendments are added to these soils to increase their fertility, not carbonate containing materials.

Unfortunately no data are available after 2006 from the statistical database of the Agricultural Economics Research Institute; hence other sources had to be used to estimate the total area of reclaimed soils. The National Plant- and Soil Protection Directorates belonging to the Ministry of Agriculture have a directorate in each of the 19 counties of Hungary. If somebody wants to apply liming for amelioration on an agricultural field, permission must be asked from

these directorates. Therefore the competent representatives of each directorate were asked for data concerning the permissions given for liming for amelioration purposes in 2008. The data they provided were used to calculate the area if liming and the amount of carbonate containing chemical amendments applied in 2008.
The carbonate containing chemical amendments used for the reclamation of acidic soils are the followings: grinded limestone, grinded dolomite, beet potash, and other by-product potashes of different origin. In certain cases (in alkaline soils) gypsum is the proper chemical amendment to reclaim salt affected soils, but carbonate containing chemical amendments is also used.
The determination of the proportion of acidic and salt affected soils where carbonate containing lime or dolomite was used is based on expert judgement. According to this judgement two third of the acidic soils are reclaimed with limestone containing amendments while 27% with dolomite. In the case of salt affected soils half of them was estimated to be reclaimed with limestone or other carbonate containing material.
According to Tier 1 method described in the GPG for LULUCF (IPCC, 2003), emission factor of 0.12 was used to estimate CO_2 emissions due the application of carbonate containing lime, and 0.122 for dolomite.

Table 7.14 *Carbon emissions from agricultural lime application in Hungary in 2008*

Climate	Soil	Type	Amount (Mg)	EF	ΔC_{CC} (Mg)
Cold	HAC	limestone	10911.2	0.12	1.3
Cold	HAC	dolomite	0	0.122	0.0
Warm	HAC	limestone	7543.216	0.12	0.9
Warm	HAC	dolomite	0	0.122	0.0
Cold	Sandy	limestone	3586	0.12	0.4
Total			**22040.4**		**2.6**

Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under cultivation.

Annual soil carbon stock change in soils

According to the summary Equation 3.3.2 of GPG for LULUCF (IPCC, 2003), the change in organic carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in cropland remaining cropland, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in cropland remaining cropland in Hungary in 2008 was 43.2 Gg.

Grassland converted to Cropland

Carbon stock change in living biomass

All carbon stock change in living woody biomass is reported under Cropland remaining Cropland category, because of aggregate removal statistics. Carbon stock change in annuals and grassland living biomass due to the conversion is not estimated.

Carbon stock change in soils

Mineral soils

The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Cropland remaining cropland sub-category (Chapter 7.2).
The areas, the relevant carbon stocks and their annual changes are reported for the sub-category Grassland converted to Cropland for the period of 1985-2008 in Table 7.15.

Table 7.15 *Carbon stocks and their changes in the Grassland converted to Cropland areas*

Year	A (1000 ha)	SOC (Mg ha^{-1})		ΔC_{CC} (Gg yr^{-1})
		0-T	0	
1985	4.89	51.74	38.18	-3.31
BY	10.59	51.74	38.18	-7.18
1986	9.78	51.75	38.18	-6.63
1987	17.11	51.73	38.18	-11.60
1988	24.45	51.74	38.18	-16.58
1989	31.78	51.72	38.18	-21.51
1990	39.11	51.57	38.18	-26.18
1991	39.11	51.55	38.18	-26.14
1992	39.11	51.39	38.18	-25.82
1993	47.25	51.01	38.18	-30.32
1994	55.38	50.57	38.18	-34.32
1995	63.52	50.33	38.18	-38.59
1996	71.66	50.16	38.18	-42.92
1997	79.79	49.95	38.19	-46.97
1998	87.93	49.83	38.19	-51.20
1999	96.07	49.76	38.24	-55.58
2000	104.20	49.73	38.24	-59.86
2001	107.17	49.61	38.24	-60.91
2002	110.13	49.55	38.25	-62.25
2003	113.10	49.49	38.25	-63.56
2004	116.07	49.48	38.26	-65.12
2005	114.14	49.49	38.26	-64.08
2006	112.22	49.47	38.27	-62.91
2007	107.85	49.47	38.38	-60.44
2008	103.48	49.47	38.18	-57.41

Liming

No liming was reported for this sub-category.

Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under cultivation.

Annual soil carbon stock change

According to the summary Equation 3.3.2 of GPG for LULUCF (IPCC. 2003), the change in organic carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux). tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in Grassland converted to Cropland in Hungary in 2008 was -57.41 Gg.

Other land converted to Cropland

Carbon stock change in soils

Mineral soils

The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Cropland remaining cropland sub-category.

The areas, the relevant carbon stocks and their annual changes are reported for the sub-category other land converted to cropland for the period of 1985-2008 in Table 7.16.

Table 7.16 *Carbon stocks and their changes in the Other Land converted to Cropland areas*

Year	A (1000 ha)	SOC ($Mg\ ha^{-1}$)		ΔC_{CC} ($Gg\ yr^{-1}$)
		0-T	0	
1985	7.30	45.13	38.18	-2.54
BY	7.31	45.13	38.18	-2.54
1986	7.31	45.13	38.18	-2.54
1987	7.31	45.13	38.18	-2.54

1988	7.31	45.13	38.18	-2.54
1989	7.31	45.13	38.18	-2.54
1990	7.32	45.13	38.18	-2.54
1991	7.32	45.13	38.18	-2.54
1992	7.32	45.13	38.18	-2.54
1993	7.36	45.13	38.18	-2.56
1994	7.41	45.13	38.18	-2.57
1995	7.45	45.13	38.18	-2.59
1996	7.49	45.13	38.18	-2.60
1997	7.54	45.13	38.18	-2.62
1998	7.58	45.13	38.19	-2.63
1999	7.62	45.13	38.19	-2.64
2000	7.67	45.13	38.24	-2.64
2001	11.02	45.13	38.24	-3.80
2002	17.06	45.13	38.24	-5.87
2003	23.10	45.13	38.25	-7.95
2004	29.14	45.13	38.25	-10.02
2005	23.88	45.13	38.26	-8.21
2006	29.92	45.13	38.26	-10.28
2007	30.92	45.13	38.27	-10.61
2008	31.92	45.13	38.38	-10.78

Liming

No liming was reported for this sub-category.

Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under cultivation.

Annual soil carbon stock change

According to the summary Equation 3.3.2 of GPG for LULUCF (IPCC. 2003), the change in organic carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}

ΔC_{CCLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in Other land converted to Cropland in Hungary in 2008 was -10.78 Gg.

7.3.3. Uncertainties and time-series consistency

As uncertainty assessment includes the degree of accuracy in land area estimates and in the default carbon accumulation and loss rates. It was considered partly on the base of the uncertainty estimates for IPCC default values taken from the *GPG for LULUCF (IPCC. 2003)* and partly based on expert judgment. Where they were available, estimates of the uncertainty of the revised global default values were used with the appropriate estimates of variability. Like in the cases of default values of stock change factors. Uncertainty in the land areas involved in land-use and management changes was estimated by expert judgement. The land area data of croplands originate from administrative records of the Hungarian Central Statistics Office. These records are based on regular agricultural surveys that cover agricultural enterprises as well as private farmers. The bigger enterprises are surveyed on a full-scope basis, while smaller private farmers on a representative basis by stratified sampling. The land area data gained from the administrative records (source: Annual Yearbooks of HCSO) were stratified further based on expert judgement as described above in the *Choice of activity data* paragraph.

Table 7.17 *Uncertainties of emissions from Cropland category*

AREAS	
Input data	**Uncertainty %**
Area stratified by soil type	25
Area stratified by climate	25
Area stratified by management	25
Area stratified by input	25
FACTORS	
Input data	**Uncertainty %**
Long-term cultivated land use	10
Full tillage	NA
Reduced tillage	6
Low input	4
Medium input	NA
High input with no manure	10
AMOUNT	
Limestone and dolomite applied	50

7.3.4. Category-specific recalculations

The carbon stock change in living biomass and in mineral soils was recalculated according to the new Approach 2 area representation method for the period of 1985-2008.
Carbon stock change in living (woody) biomass has to be undertaken to account for the new vineyard and orchard area data. Although the carbon stock change in living biomass is continued to be reported aggregately because of the aggregate removal statistics, but there was miner revision of orchard and vineyard area data fro the whole time series.
The carbon stock change in mineral soils was reported aggregately for the whole LULUCF system in the 5.A.1 Cropland remaining Cropland category. Now, the land-use changes have been specified, therefore the carbon stock change in mineral soils are reported in the remaining and the different conversion categories, respectively.

7.4. GRASSLAND (CRF sector 5.C)

7.4.1. Description of category

Although nowadays area of grasslands (meadows and pastures) accounting for 11 percent of the official area of Hungary, the total territory of grasslands in Hungary was considerably decreasing during the last three decades. While approximately 1,300,000 ha were occupied by grasslands in 1975, only 1,050,000 ha remained by 2005. From the base year the decrease of grassland areas in Hungary was 16%. Contrary to this trend, the change in the number of livestock of grazing animals (mainly cattle. sheep and geese as the livestock of horses. water buffalos and goats were not so considerable from the 1970ies) was something different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million sheep were in Hungary, and these numbers just slightly changed till 1985: 2 million cattle, 1 million geese and 3 million sheep. These numbers show that the decade of the 1980ies was the peak period concerning animal husbandry based on grazing, which was also the period of the highest natural expenditures regarding the utilization of the Hungarian grasslands: the highest fertilizer doses and the largest irrigated areas characterized this period. It can be concluded that the number of grazing animals and the intensity of grassland both started to decrease from the base year and reached its bottom in the middle of the 1990ies.
The above mentioned changes can explain the unusual trend in emissions/ removals from the Grassland category in Hungary. (Figure 7.9)
It should be noted, that the HCSO records the grasslands are used for agricultural purposes. Abandoned pastures and natural grasslands are reported as 'unproductive areas' in this statistics, therefore carbon stock change of mineral soils due to abandonment of pastures is reported in 5.C.2.5. Land converted to Other Land category.

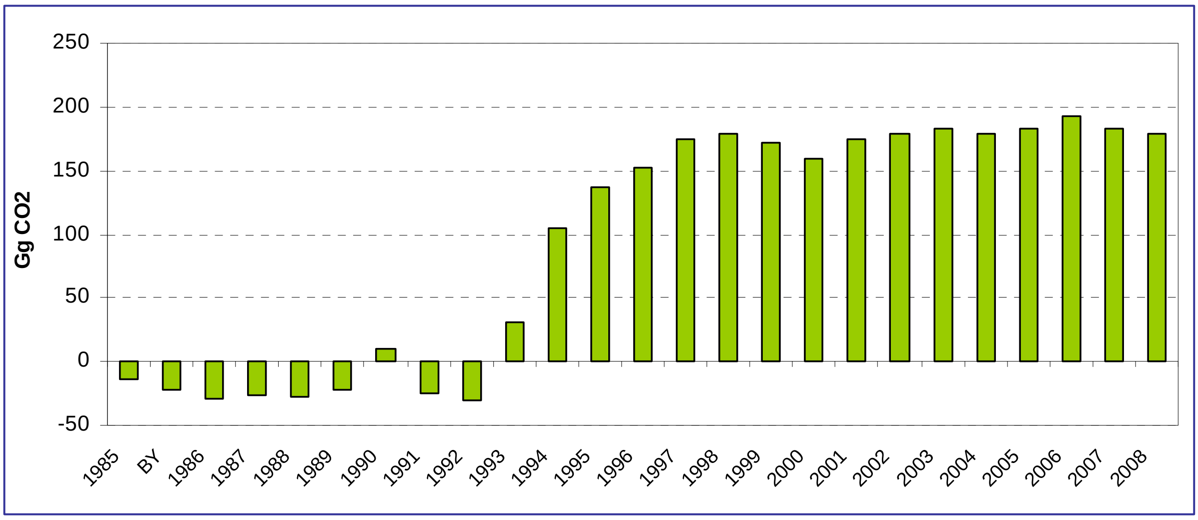


Figure 7.10 *Trend of emissions/removals from Grassland 1985-2008*

7.4.2. Methodological issues

Grassland remaining Grassland

<u>Carbon stock change in living biomass</u>

Choice of method

In Hungary grassland management practices can be considered static, so according to Tier 1 method, no change in living biomass carbon stock was estimated.

Carbon stock change in soils

Grassland management, similarly to soil cultivation and crop production, is changing in Hungary, but contrary to the other sector's slight improvements, it suffers from degradation. The improper grassland management practice has severe impacts on the soil carbon stock. Though In Hungary there are no extensive measured data yet, some results have been already achieved concerning CO_2-emission from grasslands (Nagy et al.. 2007, Zsembeli et al. 2006).

Mineral soils

Choice of method

The Tier 1 method of GPG for LULUCF (IPCC, 2003) was applied, similar to the cropland remaining cropland category. The carbon stock change was calculated from the average carbon stocks of the current and the formal land-use categories in the inventory year end 20 years before that. (Chapter 7.2)

Choice of activity data

In order to gain relevant activity data, the area of grasslands was stratified by soil type, climate, management and input.

Soil type

The method of the classification of the Hungarian grasslands according to soil types is based on the same approach that is described in the Cropland chapter (7.2). The grasslands in Hungary occupied four soil types from among the types that are determined in the *IPCC Good Practice Guidance for LULUCF (2003)* with following proportions of the total land in 2008.

Table 7.18 *Classification of the grasslands in Hungary by soil type in proportion to the total land in 2008*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	74.01
Low Activity Clay Mineral	4.25
Sandy	4.10
Aquic	17.64

As the proportions show, high activity clay mineral soils are dominant, similar to the case of croplands. Among others salt affected soils must be mentioned, which are very characteristic to Hungary, they are partly utilised as grasslands, mainly depending on the extent of salinization.

Climate

The principle of climatic classing, which is described in the Cropland section in details, is also relevant to the grasslands.

Management

Due to the lack of sufficient statistic data, the quality, hence the management of grasslands was determined on the base of the number of grazing animals and the level of expenditures for each soil type and climate region, taking the spatial distribution of livestock into consideration. The different species of grazing animals were standardised and expressed in livestock units. The spatial distribution of quality, utilisation, load, hence management types of grasslands were estimated on the base of genetic soil maps and climatic zone maps. Taking all these points of view into account, the following simplified categories characterise the management of the Hungarian grasslands: non-degraded, improved with medium input.

Input

According to the *GPG for LULUCF (IPCC. 2003)*, the input factors represent the level of improvement that affects primary productivity and hence carbon inputs to soil. To choose the input factors representing the grassland management in Hungary, the actual levels of fertilisation and irrigation were taken into consideration. Beyond the decrease of the number of livestock, the area of fertilised and irrigated grasslands was totally forced back parallel to the introduction of Agro-environmental Management Programme in 2002-2003, and was limited to slightly intensive planted grasslands. This was the reason why the natural succession of the pastures has started, resulting in the propagation of weeds and the degradation of the soil. Further harms were due to the unfavourable weather conditions of the last 5-6 years, when the droughty summer periods in conjunction with slight overgrazing made the situation even worse. Taking all these into consideration it can be concluded that significant changes occurred in the Hungarian grassland management during the last decades. The recent situation is that only half of the pastures in Hungary is utilised by grazing. The management, the treatment of grasslands is limited to their grazing and cutting.

Table 7.19 *Classification of the grasslands in Hungary by management in proportion to the total land in 2008*

Management category	Input category	Proportion of total grassland area (%)
non-degraded	-	99.5
improved	medium	0.5

Choice of stock change and emission factors

The categorisation is partly based on expert knowledge due to the lack of sufficient statistics about the recent management and input applied grassland management practice. Nevertheless the change in the management practice can be judged well on the base of the number of grazing animals and the degree of expenditures, while the input factors can be followed knowing the extent of fertilisation and irrigation of grasslands. The categorisation of the grasslands of Hungary has been made regarding the climate, soil type, management and input. The relevant factors applied for the calculations are indicated in Table 7.20.

Table 7.20 *Classification of the Grasslands in Hungary by climate, carbon stock and management factors in 2008*

Sub-categories				SOC_{ref}	F_{LU}	F_{MG}	F_I
Climate	Soil	Management	Input				
cold dry	HAC	non-degraded	-	50	1	1	-
cold dry	HAC	improved	medium	50	1	1.14	1
warm dry	HAC	non-degraded	-	38	1	1	-
warm dry	HAC	improved	medium	38	1	1.14	1

cold dry	LAC	non-degraded	-	33	1	1	-
cold dry	LAC	improved	medium	33	1	1.14	1
warm dry	LAC	non-degraded	-	24	1	1	-
warm dry	LAC	improved	medium	24	1	1.14	1
cold dry	sandy	non-degraded	-	34	1	1	-
cold dry	sandy	improved	medium	34	1	1.14	1
warm dry	sandy	non-degraded	-	19	1	1	-
warm dry	sandy	improved	medium	19	1	1.14	1
cold dry	aquic	non-degraded	-	87	1	1	-
cold dry	aquic	improved	medium	87	1	1.14	1
warm dry	aquic	non-degraded	-	88	1	1	-
warm dry	aquic	improved	medium	88	1	1.14	1

Calculation of carbon stock change in mineral soils

On the base of the methodology described above the areas, the relevant carbon stocks and their annual changes are reported for the sub-category Grassland remaining Grassland for the period of 1985-2008 in Table 7.21.

Table 7.21. *Carbon stocks and their changes in the Grassland remaining Grassland areas*

Year	A (1000 ha)	SOC (Mg ha^{-1})		ΔC_{CC} (Gg yr^{-1})
		0-T	0	
1985	1241.01	51.74	51.74	0.00
BY	1225.10	51.74	51.74	0.27
1986	1222.91	51.74	51.75	0.88
1987	1211.38	51.74	51.73	-0.06
1988	1198.84	51.74	51.74	0.49
1989	1186.10	51.74	51.72	-0.91
1990	1174.27	51.74	51.57	-9.86
1991	1144.92	51.74	51.55	-10.81
1992	1115.58	51.74	51.39	-19.49
1993	1095.34	51.74	51.01	-39.49
1994	1075.10	51.74	50.57	-62.44
1995	1054.87	51.74	50.33	-74.06
1996	1034.63	51.74	50.16	-81.40
1997	1014.40	51.74	49.95	-90.32
1998	994.16	51.74	49.83	-94.46
1999	973.92	51.74	49.76	-96.03
2000	953.69	51.74	49.73	-95.81
2001	945.60	51.74	49.61	-100.55
2002	937.50	51.74	49.55	-102.49
2003	929.41	51.74	49.49	-104.38

2004	921.32	51.74	49.48	-104.09
2005	918.62	51.74	49.49	-103.31
2006	915.92	51.74	49.47	-104.18
2007	905.92	51.74	49.47	-102.34
2008	900.66	51.74	49.47	-102.16

Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.

Organic soils

In Hungary no organic soils are under agricultural grassland management.

Annual soil carbon stock change

According to the summary Equation 3.4.7 of GPG for LULUCF (IPCC. 2003). The change in carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in grassland remaining grassland, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from lime application to grassland, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in grassland remaining grassland in Hungary in 2008 was -102.16 Gg.

Cropland converted to Grassland

Carbon stock change in living biomass

All carbon stock change in living woody biomass is reported under Cropland remaining Cropland category, because of aggregate removal statistics. Carbon stock change in annuals and grassland living biomass due to the conversion is not estimated.

Carbon stock change in soils

Mineral soils

The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Grassland remaining Grassland sub-category.

Calculation of carbon stock change in mineral soils

The calculation method we used was the same as it was described in the Grassland remaining Grassland sub-category (Chapter 7.3.4.1.)

On the base of the methodology described above the areas, the relevant carbon stocks and their annual changes are reported for the sub-category Cropland converted to Grassland for the period of 1985-2008 in Table 7.22.

Table 7.22 *Carbon stocks and their changes in the Cropland converted to Grassland areas*

Year	A (1000 ha)	SOC ($Mg\ ha^{-1}$)		ΔC_{CC} ($Gg\ yr^{-1}$)
		0-T	T	
1985	5.26	51.74	38.18	3.56
BY	8.76	51.74	38.18	5.94
1986	10.51	51.75	38.18	7.13
1987	10.51	51.73	38.18	7.12
1988	10.51	51.74	38.18	7.13
1989	10.51	51.72	38.18	7.12
1990	10.51	51.57	38.18	7.04
1991	26.28	51.55	38.18	17.56
1992	42.05	51.39	38.18	27.76
1993	48.14	51.01	38.18	30.89
1994	54.23	50.57	38.18	33.60
1995	60.32	50.33	38.18	36.65
1996	66.42	50.16	38.18	39.78
1997	72.51	49.95	38.18	42.68
1998	78.60	49.83	38.18	45.80
1999	84.69	49.76	38.18	49.04
2000	90.78	49.73	38.18	52.40
2001	92.58	49.61	38.18	52.89
2002	94.38	49.55	38.18	53.64
2003	96.18	49.49	38.18	54.38
2004	97.98	49.48	38.18	55.33
2005	94.52	49.49	38.18	53.42
2006	91.06	49.47	38.18	51.42
2007	92.86	49.47	38.18	52.43
2008	94.66	49.47	38.18	53.45

Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.

Organic soils

In Hungary no organic soils are under agricultural grassland management.

Annual soil carbon stock change

According to the summary Equation 3.4.7 of GPG for LULUCF (IPCC. 2003), the change in carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in grassland remaining grassland, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from lime application to grassland, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in Cropland converted to Grassland in Hungary in 2008 was 53.45 Gg.

Other land converted to Grassland

Carbon stock change in soils

Mineral soils

The choice of method and activity data, the land area stratification by soil type, climate, input and management practices and the applied stock change and emission/removal factors as well as the calculation method used were the same as it were described in the Grassland remaining Grassland sub-category.

Calculation of carbon stock change in mineral soils

The calculation method we used was the same as it was described in the Grassland remaining Grassland sub-category.

On the base of the methodology described above the areas, the relevant carbon stocks and their annual changes are reported for the sub-category Cropland converted to Grassland for the period of 1985-2008 in Table 7.23.

Table 7.23 *Carbon stocks and their changes in the Other land converted to Grassland areas*

Year	A (1000 ha)	SOC (Mg ha^{-1})		ΔC_{CC} (Gg yr^{-1})
		0-T	0	
1985	0.01	49.45	51.74	0.00
BY	0.01	49.45	51.74	0.00
1986	0.01	49.45	51.75	0.00
1987	0.02	49.45	51.73	0.00
1988	0.03	49.45	51.74	0.00
1989	0.04	49.45	51.72	0.00

1990	0.04	49.45	51.57	0.00
1991	0.05	49.45	51.55	0.01
1992	0.06	49.45	51.39	0.01
1993	0.42	49.45	51.01	0.03
1994	0.78	49.45	50.57	0.04
1995	1.14	49.45	50.33	0.05
1996	1.50	49.45	50.16	0.05
1997	1.87	49.45	49.95	0.05
1998	2.23	49.45	49.83	0.04
1999	2.59	49.45	49.76	0.04
2000	2.95	49.45	49.73	0.04
2001	3.00	49.45	49.61	0.02
2002	3.04	49.45	49.55	0.01
2003	3.09	49.45	49.49	0.01
2004	3.13	49.45	49.48	0.00
2005	3.17	49.45	49.49	0.01
2006	3.21	49.45	49.47	0.00
2007	9.06	49.45	49.47	0.01
2008	10.16	49.45	49.47	0.01

Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO_2 emissions.

Organic soils

In Hungary no organic soils are under agricultural grassland management.

Annual soil carbon stock change

According to the summary Equation 3.4.7 of GPG for LULUCF (IPCC. 2003), the change in carbon stocks in soils is

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where:
$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in grassland remaining grassland, tonnes C yr^{-1}
$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
$\Delta C_{CCOrganic}$= annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}
ΔC_{CCLime} = annual C emissions from lime application to grassland, tonnes C yr^{-1}.

Taking these components into account, the total annual soil carbon stock change in Other land converted to Grassland in Hungary in 2008 was 0.01 Gg.

7.4.3. Uncertainties and time-series consistency

As uncertainty assessment includes the degree of accuracy in land area estimates and in the default carbon accumulation and loss rates. It was considered partly on the base of the uncertainty estimates for IPCC default values taken from the *GPG* and partly based on expert judgment. Where they were available, estimates of the uncertainty of the revised global default values were used with the appropriate estimates of variability, like in the cases of default values of stock change factors. Uncertainty in the grassland areas involved in land-use and management changes was estimated by expert judgement. The land area data of grasslands originate from administrative records of the Hungarian Central Statistics Office. These records are based on regular agricultural surveys that cover agricultural enterprises as well as private farmers. The bigger enterprises are surveyed on a full-scope basis, while smaller private farmers on a representative basis by stratified sampling. The land area data gained from the administrative records (source: Annual Yearbooks of HCSO) were stratified further based on expert knowledge as described above in the *Choice of activity data* paragraph.

AREAS	
Input data	**Uncertainty %**
Area stratified by soil type	25
Area stratified by climate	25
Area stratified by management	25
Area stratified by input	25
FACTORS	
Input data	**Uncertainty %**
Land use as grassland	NA
Nominally managed (non-degraded)	NA
Improved management	10
Medium input	NA

Table 7.24 *Uncertainties of emissions from Grassland category*

7.4.4. Category-specific recalculations

The carbon stock change in mineral soils was recalculated according to the new Approach 2 area representation method for the period of 1985-2008.In the previous submissions emissions/removals in this catgory were not reported, because the carbon stock change in mineral soils was reported aggregately for the whole LULUCF system in the 5.A.1 Cropland remaining Cropland category. Now, the land-use changes have been specified, therefore the carbon stock change in mineral soils are reported in the remaining and the different conversion categories, respectively.

7.4.5. Category-specific planned improvements

Carbon stock change in living non-woody biomass due to conversion in cropland converted to Grassland category.

7.5. Wetlands (CRF sector 5.D)

Wetlands account for only 3 percent of the total area of Hungary. (Figure 7.2)
According to the national definition, areas of wetlands comprise inland marshes, peat bogs, water courses and water bodies. The Wetlands area was determined by extrapolation and interpolation from the CORINE databases for 1990, 2000 and 2006. CORINE is a land cover database therefore managed and unmanaged lands cannot be separated by it. To determine the area of flooded lands and peat lands, which is the managed area of Wetlands in terms of the GPG for LULUCF (IPCC, 2003), additional information should be used, which is currently not available.
In order to create land-use matrices, area of Wetlands was split into remaining and converted to category using the CORINE land-cover change databases, although the land-cover changes are probably not human-induced. (This assumption was strengthened by analyzing annual precipitation data. Before the acquisition dates of the satellite images which the CORINE 2000 land cover database based on, unusual high precipitation was recorded in Hungary. Therefore the increase of the area of Wetlands was due to the expansion of the marshes and water bodies.)
The emissions of the converted to Wetlands categories are not estimated due to lack of reliable area data and developed methodology. Nevertheless, these emissions could not be significant because the total Wetland area did not change remarkably due to human intervention, since wetlands are protected by law in Hungary. Hungary is among the signatories of the Ramsar Convention, therefore the preservation and the sustainable uses of Wetlands are emphasized. In 2007, altogether 28 wetlands (225,011 ha) in Hungary had been included in the Ramsar List of Wetlands of International Importance.
In this category only the area data are reported in the CRF tables.

7.6. Settlements (CRF sector 5.E)

Settlements account for 6 percent of the area of Hungary.
The area of Settlements was derived from the extrapolation and interpolation of the CORINE land cover inventories for 1990, 2000 and 2006, and satellite images for 1986. The land-use change data were determined from the CORINE land-cover change databases for the periods 1990-2000 and 2000-2006 and a spatial land-cover change database for 1985-1990 which was produced for GHG inventory purposes by the FÖMI. In this submission the area data in the remaining and in the converted to category are reported. For the estimation of emissions/removals additional data and methodology would be needed.

7.7. Other Land (CRF sector 5.F)

7.7.1. Description of category

The other land area is the residual land area of the country after the other land-use categories have been accounted.
The other land category contains the uncultivated (abandoned) agricultural lands and other unproductive areas in Hungary, which do not fall into any of the other five categories. Other land areas account for 7 percent of the total area of the country. (Figure 7.2)
The abandoned croplands are assumed to revert to natural grasslands status during set-aside and stay in the Cropland remaining cropland category until five years, because the HCSO's land-use statistics data includes them in the Cropland category until five years. After

five years these lands are reported in the HCS's land-use statistics aggregately as unproductive areas (not in use for agricultural purposes), therefore they are reported in the land converted to other land category.
In Hungary the agricultural production dropped out significantly in the last two decades. The productive land area decreased by 12% which indicates the importance of the land converted to Other Land category in Hungary.

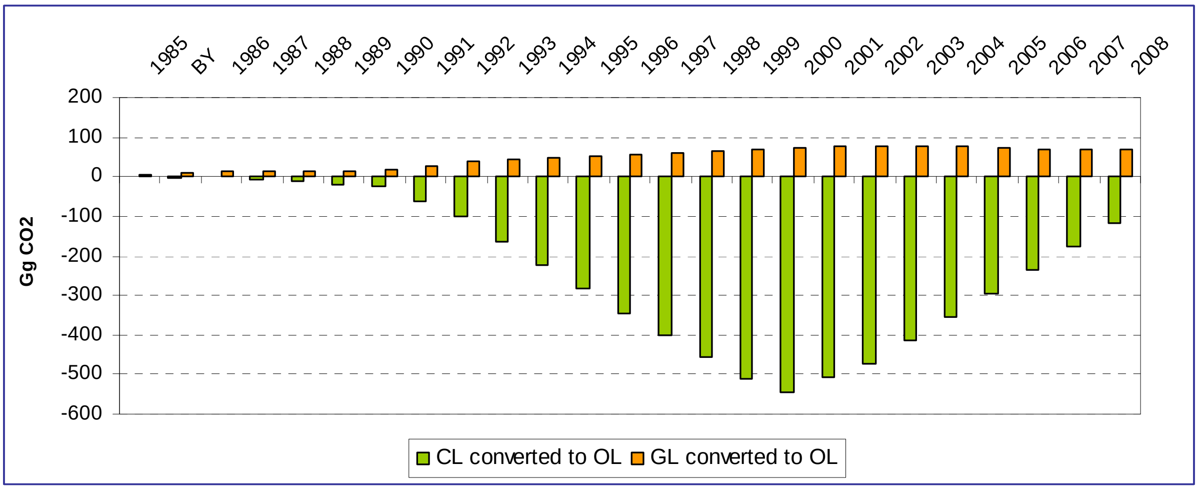


Figure 7.11 *Emissions/removals from Land converted to Other land category 1985-2008*

7.7.2. Methodological issues

Cropland converted to Other Land

In this category the effect of abandonment of croplands is reported.

Carbon stock change in living biomass

Not estimed. Probably it is neglegeble.

Carbon stock change in soils

Mineral soils

Choice of method

The IPCC Tier 1 methodolgy was applied. Similar to that it is described in Chapter 7.2

Choice of activity data

There is no data available on the area of set-asides in Hungary. Therefore the area of abandoned croplands (set-aside) was estimated from the changes of the area of Cropland reported by the HCSO. For the estimation of the area data, the CORINE land-cover change databases were taken into account as well.
The land area stratification by soil type and climate was the same as described in the Cropland remaining cropland sub-category, because the land conversion cannot have an influence on soil types and climate zones.

Choice of removal/emission factors

In accordance with the Table 3.3.4 of GPG for LULUCF (IPCC, 2003), the default value for set- asides was used: F_{LU}=0.93. For the reference soil organic carbon stock, the default values from the Table 3.3.3 of the GPG for LULUCF were applied similarly to what is described in Table 7.12.

The areas, the relevant carbon stocks and their annual changes are reported for the sub-category other land converted to cropland for the period of 1985-2008 in Table 7.25.

Table 7.25 *Carbon stocks and their changes in the Cropland converted to Other land areas*

Year	A (1000 ha)	SOC ($Mg\ ha^{-1}$)		ΔC_{CC} ($Gg\ yr^{-1}$)
		0-T	0	
1985	0.00	38.18	45.13	0.00
BY	1.67	38.18	45.13	0.58
1986	0.00	38.18	45.13	0.00
1987	5.00	38.18	45.13	1.74
1988	10.70	38.18	45.13	3.72
1989	15.60	38.18	45.13	5.42
1990	18.69	38.18	45.13	6.50
1991	48.88	38.18	45.13	16.98
1992	79.06	38.18	45.13	27.47
1993	127.11	38.18	45.13	44.17
1994	175.16	38.18	45.13	60.87
1995	223.21	38.18	45.13	77.56
1996	271.26	38.18	45.13	94.26
1997	314.31	38.18	45.13	109.22
1998	356.66	38.19	45.13	123.93
1999	399.81	38.19	45.13	138.93
2000	444.76	38.24	44.87	148.71
2001	414.58	38.24	44.87	138.61
2002	384.39	38.24	44.87	128.52
2003	336.34	38.25	44.87	112.46
2004	288.29	38.25	44.87	96.39
2005	240.25	38.26	44.87	80.35
2006	192.20	38.26	44.87	64.29
2007	144.15	38.27	44.87	48.23
2008	96.10	38.38	44.88	32.17

Grassland converted to Other Land

In this category the effect of abandonment of pastures is reported.

Carbon stock change in living biomass

Not estimated. Probably it is negligible.

Carbon stock change in soils

Mineral soils

Choice of method

The IPCC Tier 1 methodology was applied, similarly to what is described in Chapter 7.2

Choice of activity data

There is no area data available on the abandonment of pastures in Hungary. Therefore the area of abandoned grasslands was estimated from the changes of the area of Grassland reported by the HCSO. For the estimation of the area data, the CORINE land-cover change databases were taken into account as well.
The land area stratification by soil type and climate was the same as described in the Grassland remaining cropland sub-category, because the land conversion cannot have an influence on soil types and climate zones.

Choice of removal/emission factores

In accordance with the Table 3.4.5 of GPG for LULUCF (IPCC, 2003), the default values for native grassland (non-degraded) were used: F_{LU}=1, F_{MG}=1, F_I=1. For the refence soil organic carbon stock the default values from the Table 3.3.3 of the GPG for LULUCF were applied similarly to what is described in Table 7.20.

Calculation of carbon stock change in mineral soils

The used calculation method was the same as described in the Grassland remaining Grassland sub-category.
On the basis of the methodology described above, the areas, the relevant carbon stocks and their annual changes are reported for the sub-category Cropland converted to Grassland for the period of 1985-2008 in Table 7.26.

Table 7.26 *Carbon stocks and their changes in the grassland converted to other land areas*

Year	A (1000 ha)	SOC ($Mg\ ha^{-1}$)		ΔC_{CC} ($Gg\ yr^{-1}$)
		0-T	0	
1985	16.84	51.74	49.45	-1.92
BY	24.88	51.74	49.45	-2.84
1986	27.88	51.74	49.45	-3.18
1987	29.92	51.74	49.45	-3.42
1988	32.96	51.74	49.45	-3.76
1989	36.21	51.74	49.45	-4.13
1990	38.55	51.74	49.45	-4.40
1991	65.73	51.74	49.45	-7.50
1992	92.91	51.74	49.45	-10.61
1993	103.58	51.74	49.45	-11.83
1994	114.48	51.74	49.45	-13.07
1995	124.90	51.74	49.45	-14.26
1996	135.56	51.74	49.45	-15.48

1997	146.23	51.74	49.45	-16.70
1998	156.89	51.74	49.45	-17.91
1999	167.55	51.74	49.45	-19.13
2000	178.21	51.74	49.45	-20.35
2001	180.62	51.74	49.45	-20.62
2002	183.03	51.74	49.45	-20.90
2003	185.44	51.74	49.45	-21.17
2004	187.85	51.74	49.45	-21.45
2005	175.19	51.74	49.45	-20.00
2006	166.56	51.74	49.45	-19.14
2007	169.27	51.74	49.45	-19.32
2008	166.23	51.74	49.45	-19.05

7.7.3. Uncertainties and time-series consistency

No data available. The uncertainties in reported emissions and removals are probably large, because there is no area data available on abandonment of pastures and croplands in Hungary. The area data used in the calculation based on estimation.

7.7.4. Category-specific recalculations

The carbon stock change in mineral soils was recalculated according to the new Approach 2 area representation method for the period of 1985-2008. In the previous submissions emissions/removals in this category were not reported, because the carbon stock change in mineral soils was reported aggregately for the whole LULUCF system in the 5.A.1 Cropland remaining Cropland category. Now, the land-use changes have been specified, therefore the carbon stock change in mineral soils are reported in the remaining and the different conversion categories, respectively.

7.7.5. Category-specific planned improvements

None.

7.8. Non-CO2 emissions

7.8.1. Direct N_2O emissions from fertilization (CRF sector 5(I))

Hungary has an aggregate fertilization database, which derives from sales statistics. Fertilization in the different land-use categories cannot be distinguished. The total nitrogen content of the used fertilizer is taken into account under the Agriculture sector.

7.8.2. N_2O emissions from drainage of soils (CRF sector (5(II))

Parties do not have to prepare estimates for the categories contained in appendices 3a.2, 3a.3. Hungary does not have sufficient information to prepare estimates in this category.

7.8.3. N_2O emissions from disturbance associated to land-use conversion to Cropland (CRF sector 5(III))

This category has not been included in the report due to lack of an appropriate database.

7.8.4. Biomass burning (CRF sector 5(V))

In accordance with the Government Degree No. 21/2001(II.14), the on-site burning of living biomass is prohibited in Hungary. Only, the burning of slash on Forest Land is excluded. Therefore, the controlled burning of biomass and biomass burning in forest wildfires are estimated under Forest Land category, and not occur under other land-use categories.

7.9. Sector specific QA/QC and verification

At the end of 2009, the government decree (No. 345/2009) was put in force. In accordance with this legislation, the Forestry Directorate of the CAO together with the Forest Research institute make recommendation for the forestry part of the LULUCF sector. (For more details see Chapter 1.2.)
Emissions/removals from the Cropland and Grassland category are estimated by external experts on a contractual basis, and the GHG division of HMS is responsible for the QA/QC procedures. The division of tasks makes possible that different persons make the estimates of emissions and the QA/QC procedures. In addition, the new institutional arrangement for LULUCF inventory preparation means that instead of individuals institutes have become responsible for the inventory preparation.

The LULUCF QC measures are based on the General QC procedures (Tier 1) of *GPG (IPCC, 2000)*, Chapter 8.

The main topics of our QC activity in LULUCF sector:

- Check and verification of the activity (area) data, cross checks of national and international land-use datasets (HCSO's land-use database, CORINE land cover databases and FAO land-use dataset).
- Check the applied methodology
- Check of conversion factors and units through the calculation process
- Data, calculation system and methodology archiving
- Consistency check (time series are calculated consistently)

7.10. Sector specific planned improvements

Our main goal is to fulfill the reporting requirements arising from the Kyoto Protocol.

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8. Waste (CRF sector 6.)

8.1. Overview of sector

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, CH_4, and N_2O). One peculiarity of the sector is that a part of the carbon-dioxide emissions is generated from biological (biogenic) sources and this CO_2 emissions are either reported as carbon stock change in the LULUCF sector or do not need to be accounted for (e.g annual crops).

The major part of municipal solid wastes is treated by managed disposal and a smaller part by reuse, incineration or other means. The average specific municipal household waste generation rate was 1.2 to 1.3 kg/capita/day recently.

Compared to the last inventory, the most significant change was that emissions from waste incineration for energy purposes had been re-calculated and re-allocated to the energy sector.

The waste sector with 3725.37 Gg CO_2 equivalent represented 5.1% of total national GHG emissions in 2008. In the base year, total GHG emissions from the waste sector amounted to 2972.03 Gg CO_2 equivalent which accounted for 2.6% of total national GHG emissions. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+25.3%). However, the growth of emissions seemed to be stopping in recent years, moreover, a reduction of 3.4% could be observed between 2005 and 2008. In all the years, the largest category was solid waste disposal on land, representing 78.7% in 2008, followed by wastewater handling (19.5%) and waste incineration (1.8%). Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network, whereas emissions from waste disposal sites have increased until the mid of this decade as it can be seen in Figure 8.1.

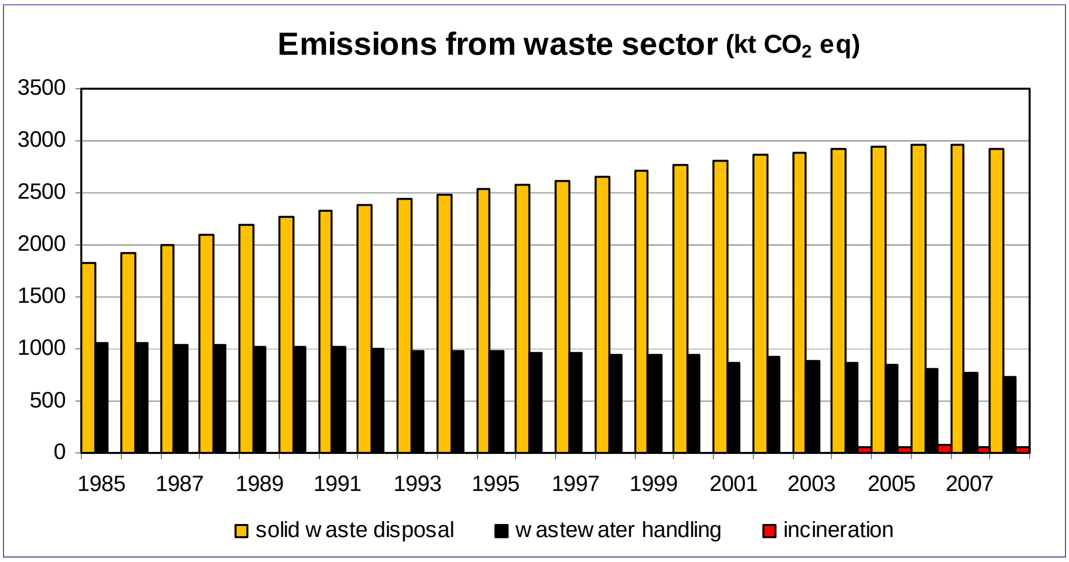

Figure 8.1. *The trend of emissions of the different categories in waste sector*

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. Under 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 flaring. 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.

8.2.2. Methodological issues

Emissions were calculated using a first order decay methodology, as response to the recommendations of the ERT in 2007. For the calculations, the IPCC Waste Model from the 2006 IPCC Guidelines was used. The FOD method 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.

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. In 2007, for the purpose of comparison, the methane emissions were 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 was around 5%. At the same time, the FOD method gave 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.

Formerly, as basic activity data the amount of removed municipal solid waste, which was published by the Hungarian Central Statistical Office in the Statistical Yearbook of Hungary and Environmental Statistical Yearbook of Hungary, were used. 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 recent 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).

The FOD method requires a quite long time series. The default first year in the IPCC Waste Model is 1950. As the eldest data which can be found in statistical publications are for 1975, extrapolation had to be made. For this purpose, a similar pattern as in Figure 8.2 had been used. This figure was taken from a university textbook sponsored by the Ministry of Education and Culture.

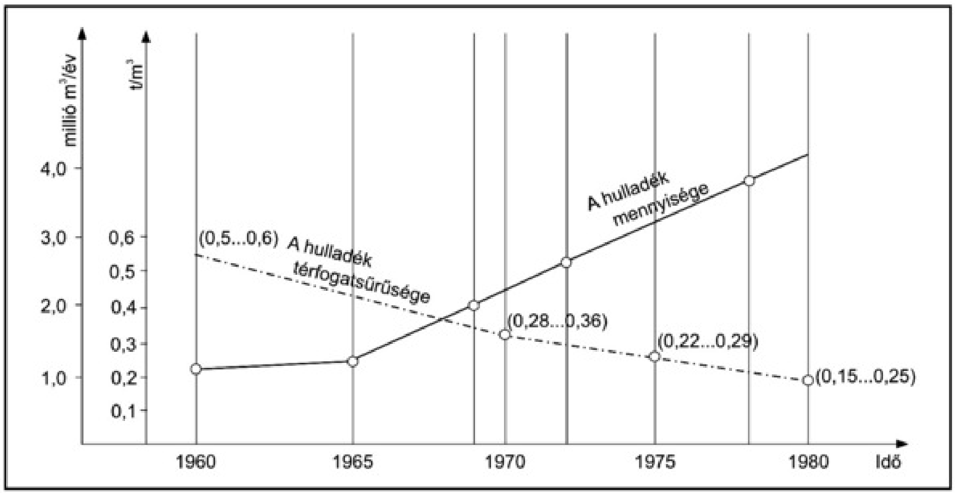

Figure 8.2. *The loosening trend of municipal solid waste in Budapest. The solid line denotes the amount of waste while the dotted line shows the decrease of volume-density. Source:* (http://www.hik.hu/tankonyvtar/site/books/b108/).

Before 2001, the amount of removed solid waste was reported in volume units (m^3), therefore these data had to be converted to mass unit using the gravimetric density (t/m^3) as an important physical characteristic of the waste. Between 1975 and 2000, the value of this parameter decreased from 0.3 t/m^3 to 0.2 t/m^3 based on the data of the Statistical Office. Both international and national studies suggested that the mass of municipal solid waste increased hardly while waste volumes increased drastically all over the world, which is reflected in decrease of the gravimetric density. 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 which can be seen clearly in Fig. 8.2. To summarize the above, the following densities were used for conversion from volume to waste units:

Table 8.1. *Waste densities used for conversion*

	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. Recently, hygienic waste (e.g. nappies) has been added to the categories. 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 (0.16) between the default values representative for food (0.15) and for garden (0.2) were chosen.

Table 8.2. *Used DOC content of different MSW components*

	IPCC GPG	IPCC 2006 GL.	Used values
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 of hygienic w.	-	0.24	0.24
DOC_F	0.77	0.5	0.5

Otherwise, default parameters of the IPCC waste model typical of dry temperate climate were used. The methane generation rate constants (k) were between 0.04 and 0.06 depending on waste type with an average value of 0.05. The default zero oxidation factor was kept, as well as the 50% fraction of methane in developed gas and the 6 month of delay time.
The amount of recovered CH_4 was calculated on the basis of energy production data obtained from the 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 will be needed.
The following table summarizes our calculations.

Table 8.3. *Summary of activity data and the resulting emissions*

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	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%	4%		**124.2**	164.7
1998	3575	18%	6%	31%	3%		**126.5**	171.1
1999	3688	20%	5%	31%	3%		**129.0**	180.6
2000	3799	14%	4%	41%	1%		**131.7**	165.1
2001	3696	16%	3%	41%	2%		**134.1**	170.0
2002	3717	16%	3%	31%	2%		**136.4**	155.1

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
2003	3966	16%	3%	30%	3%		**137.7**	160.1
2004	3978	15%	3%	31%	2%		**139.2**	166.7
2005	4072	15%	3%	29%	2%	0.0	**140.5**	165.1
2006	3902	16%	4%	24%	3%	0.9	**140.8**	152.0
2007	3477	11%	4%	25%	3%	1.7	**140.7**	111.4
2008	3494	13%	4%	24%	3%	1.7	**139.7**	123.2
Trend	**-13%**						**+53%**	**-31%**

8.2.3. 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.

8.2.4. QA/QC information

The compiler institute has now direct access to the Waste Management Information System maintained by the Ministry of Environment and Water. The calculations in the IPCC Waste Spreadsheet Model have been saved and archived for future reviews.

8.2.5. Recalculation

No recalculation was made. However, minor inconsistencies between the CRF tables and the NIR were removed as suggested by the ERT (ARR 97.)

8.2.6. Planned improvements

Following the recommendation of the ERT, we will seek for more justification of our assumption that illegally disposed waste does not lead to significant CH_4 emissions (ARR 95.). We expect more complete recovery data in the future, and we will search for waste composition data representative for other parts of the country (ARR 96.)

8.3. Wastewater treatment (CRF sector 6.B.)

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

8.3.1. Source category description

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, therefore N_2O emissions from human sewage are also part of the inventory.

8.3.2. Methodological issues

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 emitters were obtained from the regional inspectorates for environment, nature and water. Besides, 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 default BOD value was confirmed by Hungarian experts of the Ministry of Environment and Water as well and 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 [1000m^3/year] and the *emitted* 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, limited data were available on the industrial wastewater generation in individual sectors, especially for the initial years of the calculation period. Therefore a few years ago, 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).
However, the used TOW data for industrial wastewater seemed not to be correct, especially if they were compared with the data of similar countries or data from the literature. Therefore in 2008 we started to use *COD values per wastewater output* as given in Table 6.9 in the 2006 Guidelines. Special emphasis was given to industries with high COD output, e.g. food and beverage, paper and pulp, chemical industry. The difference between the new and the formerly used activity data can be as big as an order of magnitude. The compiler institute expects to have direct access to the wastewater information system in the near future, therefore more detailed data will be available to refine the calculations.

For the calculation of the *emission factor* (EF), the default maximum CH_4 producing capacities of 0.25 kg CH_4/kg COD and 0.6 kg CH_4/kg BOD were used for industrial and domestic wastewater, respectively. The choice of a proper methane conversion factor (MCF) was somewhat more difficult. (Before 2007, a value of 1 for MCF was used as if all wastewater were treated anaerobically which was definitely not the case). To calculate the

value of MCF, the following additional information was collected:

- 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 network), 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% now it's around 70%. It must be noted, however, that the percentage of dwellings connected to public sewerage network 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. Newer data indicate that the share of collected wastewater from septic system is diminishing, therefore 5% was used for 2006-2007, and 0% for 2008.
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). Using this rather high value of MCF might have lead to a little overestimation of emissions, as the internal review of the EU pointed out. For untreated and only mechanically treated wastewater zero MCF was used. In 2008, about 70% of municipal wastewater was treated at least biologically, while 5% was untreated and 25% 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.
Considering industrial wastewater, statistics show that only 20% of all wastewater output is treated at least biologically. However, this statistics relates to the volume of the wastewater. If treatment methods are analyzed on COD basis, it can be concluded that about half of the COD is treated at least biologically. The reason behind this difference is the quite large amount of wastewater output with low organic content from some industries, especially the iron and steel industry.
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 not calculated separately. Nevertheless, 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 results.

Table 8.4. *Summary of emission estimates from wastewater treatment*

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH_4	Emissions domestic wastewater [Gg CH_4]	Emissions 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*

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH_4	Emissions domestic wastewater [Gg CH_4]	Emissions industrial wastewater [Gg CH_4]
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	5.12
2003	58%	38%	62%	2.68	27.99	4.51
2004	61%	27%	73%	3.43	27.44	4.22
2005	64%	20%	80%	3.83	26.81	4.01
2006	66%	23%	77%	6.69	25.07	3.42
2007	68%	25%	75%	7.24	23.06	*3.42*
2008	71%	30%	70%	6.69	22.19	*2.88*
Trend					***-41%***	

As required, 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)

Table 8.5. *Protein consumption and the resulting N_2O emissions*

	Protein consumption [g/capita/day]	**Nitrous oxide emission [Gg N_2O]**
Base year	100.0	0.67
1990	104.7	0.69
1995	95.0	0.62
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	105.4	0.67
2006	104.6	0.67
2007	104.6	0.66
2008	101.3	0.64
Trend	***5%***	

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 new reporting requirements. However, they do not cover

all the emitters, 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 time series of emissions from domestic wastewater is most probably consistent but it needs further verification. The industrial wastewater emissions are re-estimated only for the period 2002-2006, therefore the entire time-series is not consistent.

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

No recalculation this time.

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. Consistency of the time-series has to be verified and in case of industrial wastewater it has to be established.

8.4. Waste incineration (CRF sector 6. C.)

Emitted gases: CO_2, CH_4, N_2O
Key source: none

8.4.1. Source category description

This subsector covers only emissions from thermal waste treatment without energy recovery (D10). For the first time, emissions from waste incineration for energy purposes (R1) have been re-allocated to the energy sector. As a consequence, only 13 to 31 per cent of CO_2 emissions from all waste incineration remained in this source category between 2004 and 2008. Before 2004, only emissions from the Waste Incineration Works of Budapest were included in the inventory, therefore all the emissions were removed from here and re-

allocated to the energy industries source-category.

During waste incineration, mainly CO_2 is emitted out of which only the fossil part contributes to the total emissions. (Biogenic CO_2 emissions were calculated as well but these were included only as memo items). Methane emissions, which were estimated for the first time, are insignificant and N_2O generation is also minimal.

8.4.2. Methodological issues

For estimating CO_2 emissions, the standard calculation method was used, i.e. equation 5.11 from the Good Practice Guidance (Ch. 5 Waste) was applied. The detailed Hungarian Waste Management Information System made it possible to disaggregate the activity data (amount of incinerated waste) into different waste types according to the European Waste Catalogue (EWC codes). It might be interesting that 90 to 97 per cent of all incinerated waste in this source category was hazardous waste. Nevertheless, having these country-specific waste amount and composition data, the carbon content of the incinerated waste and the fossil (and negligible biogenic) fraction thereof could be determined by using default values from Table 2.5 and Table 2.6 in the 2006 Guidelines (Volume 5. Ch. 2). The following table summarizes our calculations.

Table 8.6. *Incerinated waste and CO_2 emissions from fossil origin*

	BY	1990	1995	2000	2004	2005	2006	2007	2008
Incinerated waste (Gg)	NO	NO	NO	NO	54.07	46.56	68.90	65.06	63.66
Fossil fraction (%)	--	--	--	--	98%	96%	99%	92%	95%
Fossil CO_2, Gg	--	--	--	--	52.19	46.98	69.93	64.05	64.12

The N_2O emissions were calculated using the default value for industrial waste from Table 5.6 in the 2006 Guidelines that is 100 g N_2O / t industrial waste. For the first time, CH_4 emissions were also estimated using an emission factor of 30 kg / TJ. For this purpose, the same mass to energy conversion factors were used as described in Ch. 3.2.6.5 of this inventory report. Both methane and nitrous oxide emissions are negligible.

8.4.3. Uncertainties and time-series consistency

Consistency of the time series needs to be investigated, as activity data start only in 2004.

8.4.4. QA/QC information

No source specific information.

8.4.5. Recalculation

By distinguishing between incineration for energy recovery and pure waste management emissions in this source category decreased significantly. However, this change is mainly due to re-allocation and not to re-calculation.

9. OTHER (CRF sector 7.)

This sector not in use.

10. RECALCULATIONS

10.1. Explanations and justifications for recalculations and their implications for emission levels and trends

Recalculation of some data-series of the inventory can be justified by several reasons. Just to name a few, QA/QC procedures, ERT recommendations, changing for higher Tier methodologies can lead to a recalculation. As a basic rule, whenever new information emerges that improves the quality or accuracy of the emission data, the emissions are recalculated. 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.

10.1.1. Road transportation: liquid fuel N_2O, CH_4 emissions

The centralized review from the previous year pointed out the still missing recalculations in the road transport sector. In 2006 the methodology of these categories was changed (see NIR 2009 submission) according to the suggestion of the ERT, but the calculations were performed only for the base years and for 2004 (see explanation in NIR 2009). The new methodology requires detailed information from vehicle categories but the databases are available only from 2000 for the inventory team. As N_2O emission from this source is now a key category, it was decided to fill the gap with the help of existing datasets and background information (e.g.: consumption of gasoline types). The generated emissions for the missing years fit in well with the trend of implied emission factor, however it is expected that these results will be refined in the future. Some minor changes occurred in the categorization of vehicles for 2004 till 2007, and they affected the emissions as well.

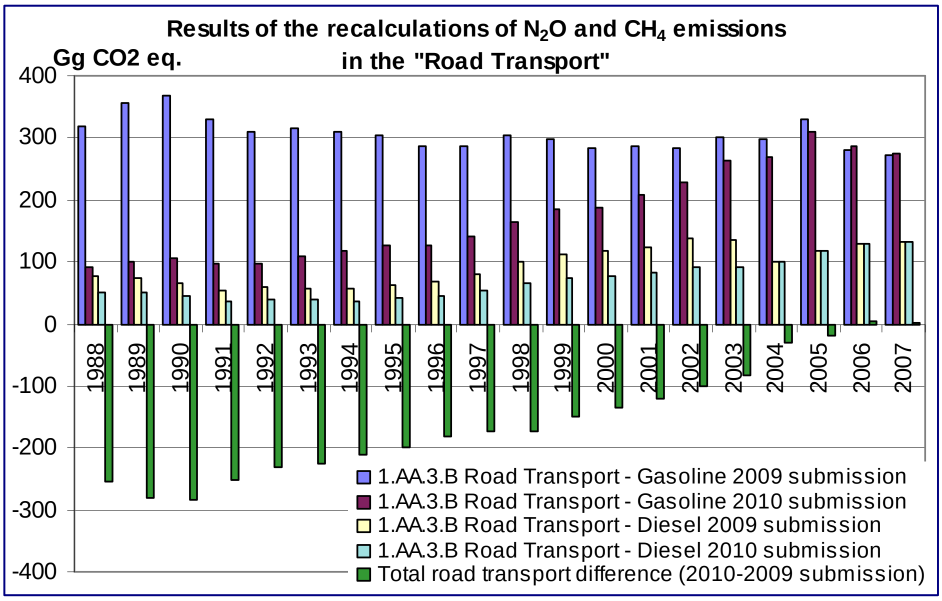

Figure 10.1. *Result of the recalculation of N_2O and CH_4 emissions in the "Road Transport"*

The figure above shows the previous and current aggregated CH_4 and N_2O emissions (in terms of CO_2 eq.) for gasoline and diesel vehicles, and the total differences in road transport category between the 2009 and current submissions for 1998 to 2007.

10.1.2. Feedstocks and non-energy use of fuels, liquid fuels, CO_2 emissions

For the first time feedstocks and non-energy use of liquid fuels were removed from the sectoral approach for the entire time-series, the CO_2 emission originated from non-combustion can be found in the *Industrial Processes Sector*. Emissions from bitumen used as feedstock for asphalt roofing and road paving with asphalt are moved to 2.A.5 and 2.A.6 sectors, however their CO_2 emissions were never calculated according to the methodology of the IPCC 1996 and 2000 guidance.
The other feedstocks and non-energy products are reported under 2.G in two aggregated categories, because the exact place of conversion of feedstock within the chemical industry is not known – presumably it is confidential data. The same aggregation was applied for non-energy use of fuels.

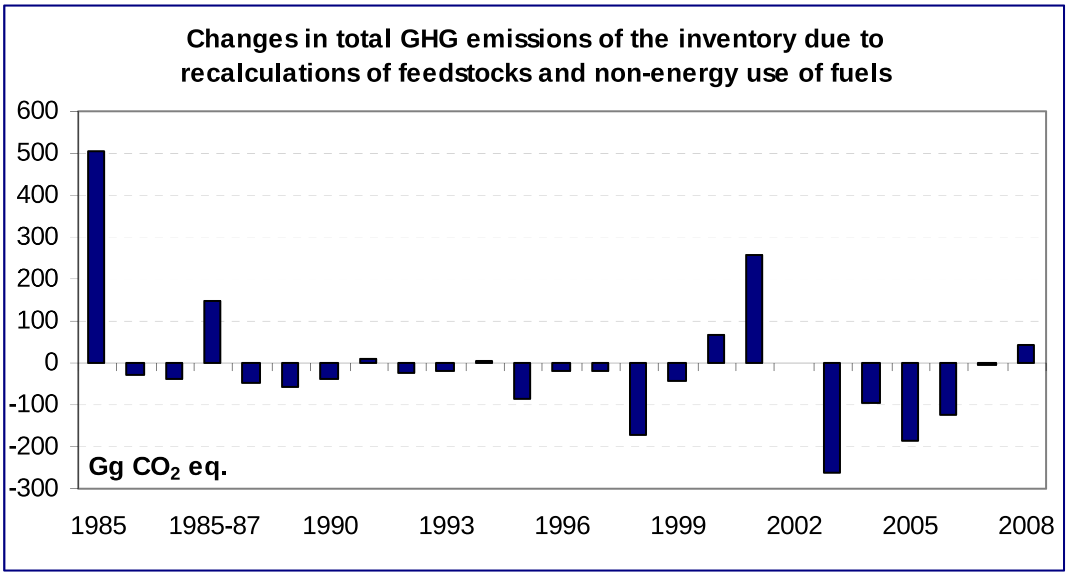

Figure 10.2. *Changes in total GHG emissions of the inventory due to recalculations of feedstocks and non-energy use of fuels*

10.1.3. Waste incineration for energy purposes, CO_2 N_2O, CH_4 emissions

As recommended by the ERT and required by the guidelines, emissions from waste incineration for energy purposes has been re-allocated from the waste sector to the energy sector. However, emissions estimation in the energy sector is somewhat different from the methodology used in the waste incineration category. For the first time, CH_4 emissions from waste incineration have been added to the inventory using the default emission factors. The resulting emissions are not significant at all. The same can be stated about N_2O emissions that were estimated the same way with the default emission factor. All in all, waste incineration contributed 250-350 Gg CO_2 eq to GHG emissions in the energy industries category and around 100 Gg CO_2 eq. to the emissions of the manufacturing industries source category, recently. It must be noted, however, that by using ETS data, total emissions from waste incineration increased by 50-60 Gg compared to previous estimations.

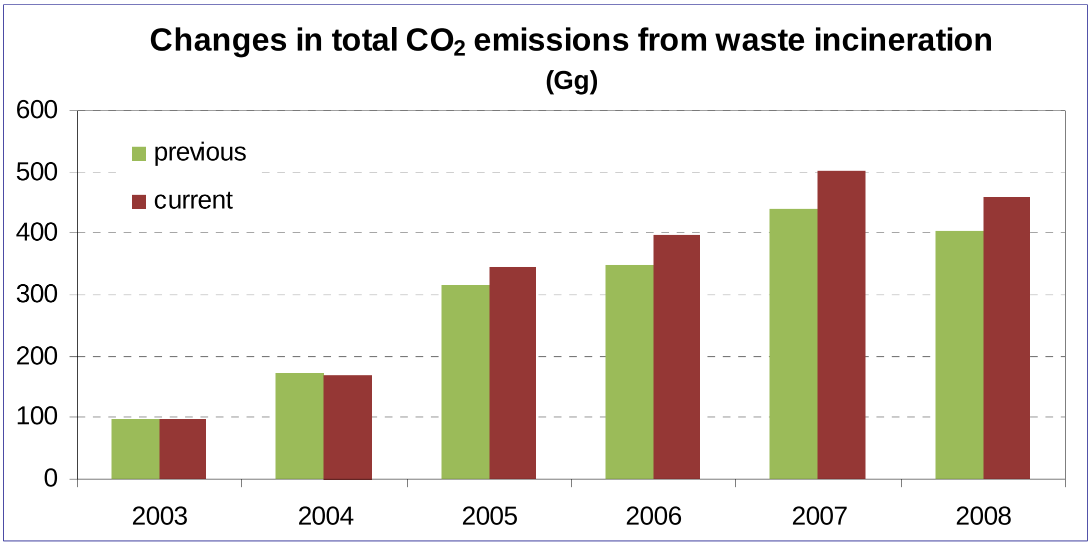

Figure 10.3. *Changes in total CO_2 emissions from waste incineration (Gg)*

10.1.4. Cement Production (CRF sector 2.A.1)

Activity and emission data have been updated. Cement plants were contacted and asked for revision of the applied activity data. Data were corrected by the quality assurances or controlling divisions of the facilities. Verified CO_2 emissions reported under the EU ETS were available for the years 2005-2008. These data were compared with each other and it came to light that data from the ETS were more accurate which was due to the fact that calculations in the ETS were based on monthly values, thus rounding error were smaller.
The figure below shows the recalculation difference of IEF CO_2/klinker compared to the previous submission.

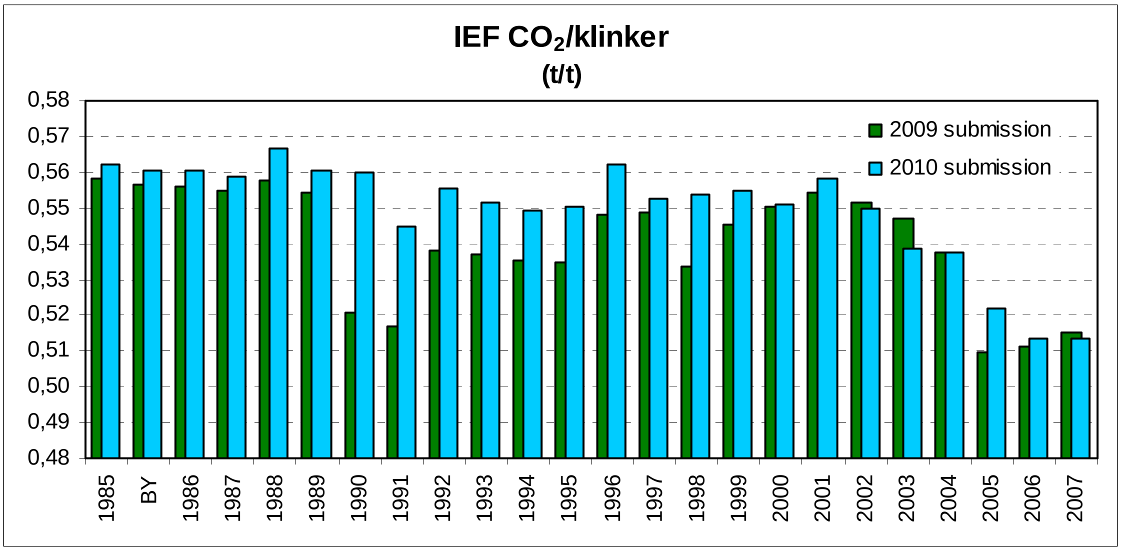

Figure 10.4. *Implied emission faktor (t/t)*

10.1.5. Nitric Acid Production (CRF sector 2.B.2)

Information about consumption of natural gas from 2007 was received from the factory. The gas was used in a new plant as a tail gas reducing agent. The amount of released carbon dioxide are estimated from the carbon content which provided by IPCC Guidelines (1997)

10.1.6. Consumption of Halocarbons and SF6 (CRF sector 2.F)

The ERT recommended several changes for Hungary, and the following were done:

- Potential emissions of HFCs aerosols/metered dose are reported instead of NE.
- Activity data from the year 1999 has been updated since the last submission. This recalculation resulted in an increase of emissions.
- In case of HFC-134a, activity data in domestic refrigeration has been included also for manufacturing.
- To use appropriate notation keys, NO instead of NE or IE, for example in commercial refrigeration C_3F_8, domestic refrigeration, fire extinguishers.
- A copying error of SF_6 use in 2.F.8 Electrical Equipment was corrected for 2007.
- Potential emissions of HFCs from foam blowing were reported instead of NE.

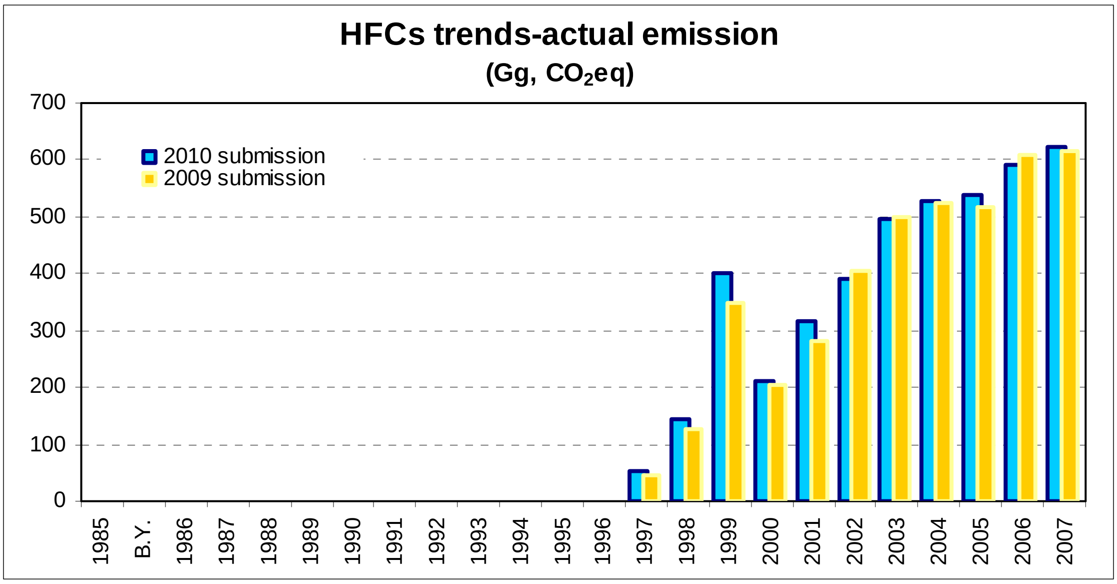

Figure 10.5. *HFCs trends (Gg CO_2 eq)*

10.1.7. Other (CRF sector 2.G)

It is a new category. The feedstock and non-energy use of fuels are reported under 2.G instead of Energy sector, because the exact place of conversion of feedstock within the chemical industry.

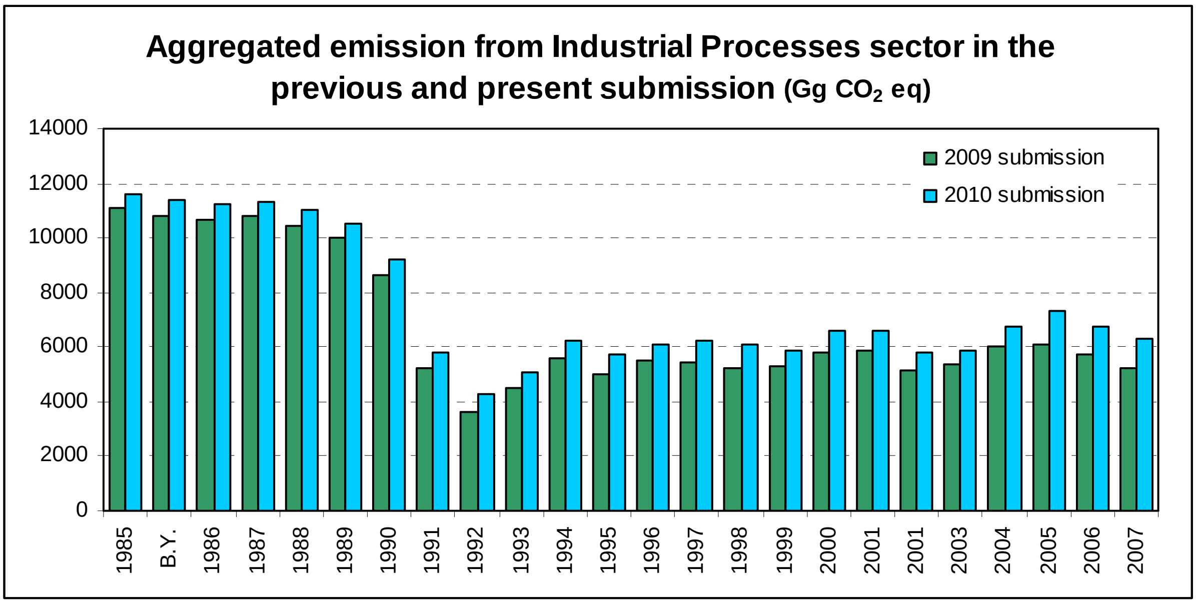

Figure 10.6. *Aggregated emission from Industrial Processes sector in 2009 submission and present submission*

10.1.8. Use of N2O (CRF sector 3.D)

Activity data from the year 1985 has been updated since the last submission. This recalculation resulted usually in a decrease of emissions but in an increases in 2005 and 2007.

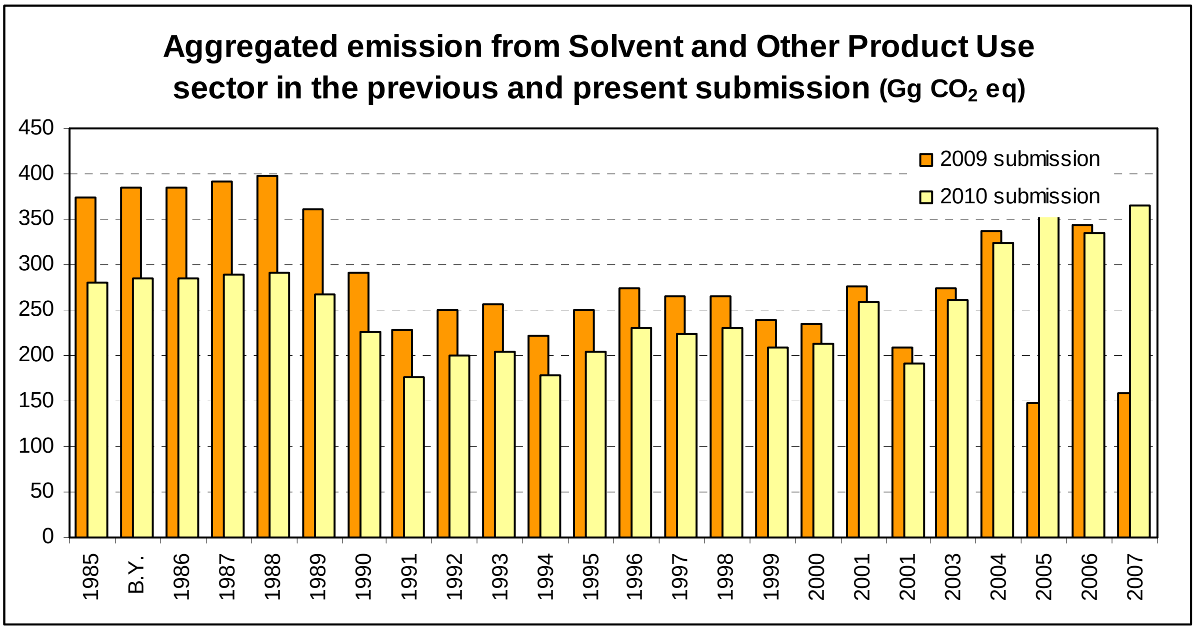

Figure 10.7. *Aggregated emission from Solvent and Other Product Use sector in 2009 submission and present submission*

10.1.9. AGRICULTURE SECTOR

The following recalculations resulted from our QA/QC procedures.
The reasons for the recalculations were as follows:

- 4.A Enteric Fermentation, CH_4 Emissions, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.
- 4.B Manure Management, CH_4 and N_2O Emissions, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.
- 4.D.1.2 Agricultural Soils, Direct N_2O-Emissions, Animal Manure Applied to Soils, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1985-2007
  Revision of Residue to crop product ratio ($Res_O/Crop_O$). Correction of values for sunflower–seed, rape seed, linseed, poppy seed, lucerne seed and seed of grass.
- 4.D.1.4 Agricultural Soils, Direct N_2O-Emissions, Crop Residues, 1986-2007
  Correction of calculation error in relation of rice and other cereals.
- 4.D.2 Agricultural Soils, Direct N_2O-Emissions, Pasture, Range and Paddock Manure, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.
- 4.D.3.1 Agricultural Soils, Indirect N_2O-Emissions, Atmospheric Deposition, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.
- 4.D.3.2 Agricultural Soils, Indirect N_2O-Emissions, Nitrogen Leaching and Run-off, 2000-2007
  Revision of activity data, new detailed activity data inclusion for Asses and Mules and Poultry livestock.

Recalculations resulted in a small, average 0.14 percent increase in emissions expressed in CO_2-eq from the Agriculture sector. Changes in emissions in CO_2-eq are between 0.06 to 0.26 percent, the smallest one refers to 1985 and the biggest one refers to 2007. The methane emission changed between -0.01 to 0.12 percent in the period 2000-2007. The N_2O emission increased by 0.08 to 0.32 percent between 1985 and 2007.

10.1.10. LULUCF SECTOR

Recalculations for LULUCF include reporting of emissions/removals of the all sub-sectors. The following are the principal changes leading to recalculations:

5.A Forest Land

- Revision of wood densities, inclusion of new country specific values.
- Inclusion of new activity data on wild fires.
- Revision of activity data of 5.A.2 Land converted to Forest Land category.
- Revision of the value of carbon fraction

5.B Cropland

- New activity data due to new area representation method.
- Revision of activity data on 5.B.1 Cropland remaining Cropland/ living biomass.

5.C Grassland

- New activity data due to new area representation method.

5.F Other Land

- New activity data due to new area representation method.

Recalculations resulted in an average 22.24 percent decrease in the removal from the sector. Changes in removals are between -91.66 to 52.46 percent, in 1985 and 2000, respectively. Nearly half of changes can be explained by the recalculation of the Forest Land category. The removals from this sub-category decreased by an average 10 percent. Changes in removals are between -32.05 to 70.81 percent. The effect of recalculations is presented in the following Table:

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2009	-3,629.0	-1,525.1	-4,555.7	-4,806.2	-5,963.3	-5,063.3	-4,238.9	-4,771.5	-5,751.7
Submission 2010	-2,213.6	-127.3	-3,081.8	-3,467.6	-4,457.0	-3,669.5	-2,910.0	-3,359.8	-4,425.4
Difference	1,415.4	1,397.9	1,473.9	1,338.5	1,506.2	1,393.8	1,329.0	1,411.6	1,326.2
Percentage change	-39.0%	-91.7%	-32.4%	-27.9%	-25.3%	-27.5%	-31.4%	-29.6%	-23.1%
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Submission 2009	-5,751.7	-8,522.2	-8,961.4	-8,642.7	-3,494.6	-3,535.0	-5,772.0	-2,505.7	-857.0
Submission 2010	-4,425.4	-6,275.5	-6,750.8	-6,796.0	-2,889.4	-2,956.8	-3,986.0	-2,352.4	-1,306.5
Difference	1,326.2	2,246.7	2,210.6	1,846.7	605.2	578.2	1,785.9	153.3	-449.6
Percentage change	-23.1%	-26.4%	-24.7%	-21.4%	-17.3%	-16.4%	-30.9%	-6.1%	52.5%
	2001	2002	2003	2004	2005	2006	2007		
Submission 2009	-2,587.9	-1,782.5	-4,517.6	-4,229.3	-4,645.4	-4,137.9	-4,164.6		
Submission 2010	-2,641.5	-1,856.8	-3,612.2	-2,627.5	-4,665.8	-2,665.2	-2,972.5		
Difference	-53.5	-74.2	905.4	1,601.7	-20.5	1,472.6	1,192.1		
Percentage change	2.1%	4.2%	-20.0%	-37.9%	0.4%	-35.6%	-28.6%		

10.2. Planned improvements to the inventory

Our project to increase the consistency between different emission databases, especially the GHG inventory, the ETS data, NAMEA data, and the E-PRTR data, will be continued. Also the development of a common central database is planned.

The inventory division has got recently direct access to emission reports from polluters under the governmental decree 21/2001. We started to analyze the dataset with the aim to update the current country specific emission factors.

It is planned to investigate the relation of fugitive emission from natural gas pipelines and emission from *residential* and *commercial/institutional* natural gas consumption.

The present consistency problems will be analyzed further, especially in cement production and industrial wastewater categories.

Agriculture:

- Enteric Fermentation: Improvement of the calculation method of CH_4 emission from enteric fermentation in the case of Dairy Cattle and Non-Dairy Cattle categories. Introduction of Tier 2 method for the other livestock categories.
- Manure Management, CH_4: Improvement of the calculation method of CH_4 emission from manure management for all livestock categories.
- Manure Management and Agricultural Soils, N_2O: Introduction of Tier 2 method as well as elaboration of country-specific values for all livestock categories regarding N-excretion.
- Improvement of uncertainty assessment.

LULUCF:

Our main goal is to fulfil the reporting requirements arising from the Kyoto Protocol.

Forestry:
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 for the Kyoto reporting to improve documentation.
In 2008 a new method was designed and introduced into the National Forest Database to identify the deforested areas. The operation of this data collection in the introductory year will be revised later, however, the current submission is based on this data, and after the first year, we have a chance to improve data quality.
There are plans to collect data on some DOM pools (i.e., litter and lying deadwood based on a systematic sampling grid of 4×4 km, used in ICP Forest, Forest Focus and Life+ programs. Over a thousand plots will be surveyed in 2010.
5.B Cropland, 5.C Grassland
Estimation of carbon stock change in living (non-woody) biomass due to conversions in 5.B Cropland and 5.C Grassland categories.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11. KP-LULUCF

12. Information on accounting of Kyoto units

Annual Submission Item	Reference / Information
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	The SEF Report is submitted as a separate file created by the UNFCCC SEF Application v1.2. The filename is: [SEF_HU_2010_1_11-18-38 11-1-2010.xls]. (Report R-1)
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	There have been 10 discrepant transactions during the reporting period, pursuant to 15/CMP.1 annex I.E paragraph 12. The response codes were 4003 and 4010. Detailed information can be found in the Excel file named [SIAR Reports 2009-HU v1.0.xls] on sheet "R2". (Report R-2)
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2009. The above statement can also be found in the Excel file named [SIAR Reports 2009-HU v1.0.xls] on sheet "R3". (Report R-3)
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred in 2009. The above statement can also be found in the Excel file named [SIAR Reports 2009-HU v1.0.xls] on sheet "R4". (Report R-4)
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2009. The above statement can also be found in the Excel file named [SIAR Reports 2009-HU v1.0.xls] on sheet "R5". (Report R-5)

15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No discrepancies have occurred in the reporting period..
15/CMP.1 annex I.E Publicly accessible information	Publicly accessible information is available at https://www.hunetr.hu/crweb/ under the "Nyilvános Jelentések" menu item. Currently public reports are only available in Hungarian, as the software does not handle multiple languages.
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve, calculated in accordance with the annex to decision 18/CP.7, based on the inventory of 2008 (NIR submission 2010) is: 368,365,605 Mg CO_{2eq}. For details of the calculation, please see 12.5.

12.5 Calculation of the commitment period reserve (CPR)

The commitment period reserve is calculated in accordance with decision 11/CMP.1 (Annex Article 6.):

"Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest."

At the time of the preparation of this document the "most recently reviewed inventory" is the inventory of 2007 (National Inventory Submissions 2009), however the inventory of 2008 (National Inventory Submissions 2010) is already available and by the time this document will be assessed, the inventory of 2008 might already be the "most recently reviewed inventory", so CPR is calculated based on 2008's data.

<u>Calculations:</u>

(a) On the basis of assigned amount:
90% of the assigned amount of Hungary
$$542{,}366{,}600 \cdot 0{,}9 = 488{,}129{,}940 \mathrm{MgCO}_{2\,\mathrm{eq}}$$

(b) On the basis of the inventory of 2008 (NIR2010)
five times the inventory of 2008
$$73{,}673{,}121 \cdot 5 = 368{,}365{,}605 \mathrm{MgCO}_{2\,\mathrm{eq}}$$

13. Information on changes in national system

At the very end of 2009, a new government decree (No. 345/2009) on data provision relating to GHG emissions was put into force. This decree confirmed the minister's leading role in the national system on the one hand, and the designation of the Hungarian Meteorological Service as the compiler institute on the other. As a new element, the participation of the Forestry Directorate of the Central Agricultural Office (CAO) together with the Forest Research Institute is now formalized by this decree. These two institutes are responsible for the forestry part of the LULUCF sector and for the supplementary reporting on LULUCF activities under Articles 3.3 and 3.4 of the Kyoto Protocol by way of making recommendations to HMS of the content of the inventory. In addition, this government decree prescribes compulsory data provision for GHG inventory purposes for numerous governmental bodies and emitters.

In July 2009, in an official letter of the NFP for the UNFCCC, Dr. Tibor Faragó, refined the contact information. While doing so, he confirmed that all the GHG inventory related tasks both in the context of the Convention and its Kyoto Protocol will be supervised and fulfilled by the Climate Policy Unit in close cooperation with a unit established at the Met. Service dedicated just to this task. The GHG focal point on Mr. Faragó's behalf in the ministry is Ms. Mónika Gottfried, NFP/GHG and at the implementation level the key responsible person remains Mr. Gábor Kis-Kovács, GHG Inventory Focal Point. The contact information is the following:

- Ms. Mónika Gottfried, NFP/GHG, Hungary, Ministry of Environment and Water (Környezetvédelmi és Vízügyi Minisztérium), Fő utca 44-50 / H-1011 Budapest, Hungary, gottfried@mail.kvvm.hu
- Dr/Ms. Erika Hasznos, director, Climate Policy Unit, Ministry of Environment and Water (Környezetvédelmi és Vízügyi Minisztérium), Fő utca 44-50 / H-1011 Budapest, Hungary, hasznose@mail.kvvm.hu
- Mr. Gábor Kis-Kovács, GHG Inventory Focal Point, Hungarian Meteorological Service (OMSZ), GHG Division, Kitaibel Pál utca 1 / H-1024 Budapest, Hungary, kiskovacs.g@met.hu

It is worth mentioning that the inventory division at the Met. Service has got direct access to emission reports from polluters under the governmental decree 21/2001 held by the Ministry of Environment and Water.

14. Information on changes in national registry

Changes to Hungary's National Registry are reported for the following period: from 16 April 2009 to 15 April 2010.
The baseline for the reported changes is the last Standard Initial Report (submitted on 15 April 2009) and the Readiness Documentation. Changes to the national registry during the reporting period are detailed below. The reported information has been complied in accordance with the provisions of the "SIAR Reporting Requirements and Guidance for Registries (v4.3)".
In the reporting period Hungary has replaced the GRETA v3.0 registry software with the Community Registry (CR v3.2) software. The software migration concluded on the 5th of October. An updated Readiness Documentation along with its Supporting Documentation is submitted as part of the annual submission.
At the end of the year a SEF solution was introduced to the registry software, which has been certified by the ITL Administrator.

Reporting Item	Reference / Information
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The registry administrator designated by Hungary to maintain the national registry - National Inspectorate for Environment, Nature and Water - has not changed, however there are some changes in the contact information. For details please see the information below
15/CMP.1 annex II.E paragraph 32.(b) Change of cooperation arrangement	There is no change in this subject. Hungary's national registry is operated as a standalone registry.
15/CMP.1 annex II.E paragraph 32.(c) Change to database or the capacity of National Registry	In 2009 the registry software has been changed from GRETA v3.0 to CR v3.2. Application server hardware and operating system is unchanged, but the web server is Weblogic 8.1 SP6 instead of IIS 6.0. The hardware infrastructure has changed on the database side. For the new software, Oracle database is used instead of MS SQL. The database server hardware is completely replaced. The changes are detailed in the updated Readiness Questionnaire and its Supporting Documentation.
15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	In 2009 the registry software has been changed from GRETA v3.0 to CR v3.2. The software change has been completed after internal testing, successful DES Annex H and CITL tests. The software exchange process has been carried out in line with the requirements of the Version Change Management and the provisions of the Migration Plan as agreed with the ITL and CITL Administrators. The changes are detailed in the updated Readiness Questionnaire and its Supporting Documentation.
15/CMP.1 annex II.E paragraph 32.(e) Change of discrepancies procedures	No change in the discrepancies procedures in the reporting period.

15/CMP.1 annex II.E paragraph 32.(f) Change of Security	No change in the security in the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change of list of publicly available information	No change in the publicly accessible information in the reporting period.
32.(h) Change of Internet address	Hungary's National Registry's Internet address is unchanged. The address is: www.hunetr.hu
15/CMP.1 annex II.E paragraph 32.(i) Change of data integrity measure	No change in the data integrity measure in the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change of test results	In 2009 the registry software has been changed from GRETA v3.0 to CR v3.2. Prior to the start of the DES Annex H test, the test plan has been run on the new software. The test results will be submitted along with the Supporting Documentation of the Readiness Questionnaire.
The previous Annual Review recommendations	

Change in contact details of the Registry Administrator

The change in the contact details of the Registry Administrator are the following:
The main contact is Ms Katalin Kőbányai instead of Ms Katalin Bajsz

Name: Ms. Katalin Kőbányai
Position: Expert
Organization: National Inspectorate for Environment, Nature and Water
Address: Mészáros utca 58/a
City: H-1016 Budapest
Tel.: +36 12 24 9190
Fax: +36 12 24 9298
E-mail: kobanyai@mail.kvvm.hu

The alternative contact is Ms Ildikó Bódi instead of Ms Katalin Kőbányai

Name: Ms. Iidikó Bódi
Position: Expert
Organization: National Inspectorate for Environment, Nature and Water
Address: Mészáros utca 58/a
City: H-1016 Budapest
Tel.: +36 12 24 9190
Fax: +36 12 24 9298
E-mail: bodiil@mail.kvvm.hu

15. Information on minimization of adverse impacts in accordance with Article 3, paragraph 14