



**Hungarian Meteorological Service**  
Greenhouse Gas Inventory Division

# **National Inventory Report for 1985-2010**

**Hungary**

May 2012

**Prepared by:**

Gábor Kis-Kovács  
Head of Division

## Energy

Klára Tarczay, expert  
Katalin Kőbányai, expert  
Gábor Kis-Kovács

Industry,  
Solvent and Other Product Use

Edit Nagy, expert  
Katalin Kőbányai, expert

## Agriculture

Dr. György Borka,  
external expert  
Katalin Lovas, expert

## LULUCF

## Forest land

Péter Kottek  
Dr. Zoltán Somogyi,  
external contributors

Cropland,  
Grassland

Dr. József Zsembeli,  
external expert  
Katalin Lovas, expert

## Waste

Gábor Kis-Kovács

## CONTENT

<b>EXECUTIVE SUMMARY.....</b>	<b>5</b>
<i>ES.1. BACKGROUND INFORMATION .....</i>	<i>5</i>
<i>ES.2. SUMMARY OF NATIONAL EMISSIONS AND REMOVAL RELATED TRENDS.....</i>	<i>5</i>
<i>ES.3. OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS.....</i>	<i>7</i>
<i>ES.4. INDIRECT GREENHOUSE GASES AND SO<sub>2</sub>.....</i>	<i>10</i>
<b>1 INTRODUCTION.....</b>	<b>11</b>
1.1 BACKGROUND INFORMATION AND CLIMATE CHANGE .....	11
1.2 INSTITUTIONAL ARRANGEMENTS.....	13
1.3 INVENTORY PREPARATION .....	15
1.4 DATA COLLECTION, PROCESSING AND STORAGE .....	16
1.5 BRIEF GENERAL DESCRIPTION OF METHODOLOGIES AND DATA SOURCES USED .....	18
1.6 KEY SOURCE CATEGORIES.....	19
1.7 QA/QC INFORMATION .....	21
1.8 UNCERTAINTY.....	23
1.9 COMPLETENESS.....	23
<b>2 TRENDS IN GREENHOUSE GAS EMISSIONS.....</b>	<b>24</b>
2.1 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS .....	24
2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS.....	29
2.3 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY CATEGORY .....	31
2.4 TRENDS OF INDIRECT GASES AND SO <sub>2</sub> .....	34
<b>3 ENERGY (CRF SECTOR 1).....</b>	<b>35</b>
3.1 OVERVIEW OF SECTOR.....	35
3.2 FUEL COMBUSTION (CRF SECTOR 1.A).....	38
3.3 FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS (CRF SECTOR 1.B).....	65
3.4 REFERENCES.....	75
<b>4 INDUSTRIAL PROCESSES (CRF SECTOR 2.).....</b>	<b>77</b>
4.1 OVERVIEW OF SECTOR.....	77
4.2 EMISSION TRENDS .....	78
4.3 MINERAL PRODUCTS (CRF SECTOR 2.A).....	81
4.4 CHEMICAL INDUSTRY (CRF SECTOR 2.B).....	91
4.5 METAL PRODUCTION (CRF SECTOR 2.C).....	98
4.6 OTHER PRODUCTION (CRF SECTOR 2.D).....	104
4.7 PRODUCTION OF HALOCARBONS AND SF <sub>6</sub> (CRF SECTOR 2.E) .....	104
4.8 CONSUMPTION OF HALOCARBONS AND SF <sub>6</sub> (CRF SECTOR 2.F) .....	104
4.9 OTHER (CRF SECTOR 2.G).....	120
4.10 REFERENCES.....	123
<b>5 SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3.).....</b>	<b>124</b>
5.1 OVERVIEW OF THE SECTOR .....	124
5.2 SOLVENT USE (CRF SECTOR 3.A, 3.B) .....	125
5.3 USE OF N <sub>2</sub> O (CRF SECTOR 3.D) .....	126
<b>6 AGRICULTURE (CRF SECTOR 4.).....</b>	<b>128</b>
6.1 OVERVIEW OF SECTOR.....	128
6.2 ENTERIC FERMENTATION (CRF SECTOR 4.A.) .....	137
6.3 MANURE MANAGEMENT (CRF SECTOR 4. B.).....	146
6.4 RICE CULTIVATION (CRF SECTOR 4.C.).....	156
6.5 AGRICULTURAL SOILS (CRF SECTORS 4.D.1, 4.D.2 AND 4.D.3).....	157
6.6 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF SECTOR 4.F.) .....	162
6.7 REFERENCES.....	164
<b>7 LAND-USE, LAND-USE CHANGE AND FORESTRY (CRF SECTOR 5.).....</b>	<b>168</b>
7.1 OVERVIEW OF SECTOR.....	168

7.2	LAND AREA REPRESENTATION USED IN THE HUNGARIAN INVENTORY .....	172
7.3	FOREST LAND (CRF SECTOR 5.A) .....	181
7.4	CROPLAND (CRF SECTOR 5.B) .....	207
7.5	GRASSLAND (CRF SECTOR 5.C) .....	223
7.6	WETLANDS (CRF SECTOR 5.D) .....	233
7.7	SETTLEMENTS (CRF SECTOR 5.E) .....	235
7.8	OTHER LAND (CRF SECTOR 5.F) .....	240
7.9	NON-CO2 EMISSIONS .....	241
7.10	UNCERTAINTY AND TIME-SERIES CONSISTENCY .....	242
7.11	SECTOR SPECIFIC QA/QC AND VERIFICATION .....	244
7.13	SECTOR SPECIFIC PLANNED IMPROVEMENTS .....	250
7.14	SOURCES - REFERENCES .....	251
<b>8</b>	<b>WASTE (CRF SECTOR 6.) .....</b>	<b>253</b>
8.1	OVERVIEW OF SECTOR .....	253
8.2	SOLID WASTE DISPOSAL IN LANDFILLS (CRF SECTOR 6.A.) .....	254
8.3	WASTEWATER TREATMENT (CRF SECTOR 6.B.) .....	258
8.4	WASTE INCINERATION (CRF SECTOR 6. C.) .....	262
<b>9</b>	<b>OTHER (CRF SECTOR 7.) .....</b>	<b>264</b>
<b>10</b>	<b>RECALCULATIONS .....</b>	<b>265</b>
10.1	EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS AND THEIR IMPLICATIONS FOR EMISSION LEVELS AND TRENDS .....	265
10.2	ENERGY SECTOR .....	265
10.3	INDUSTRY .....	271
10.4	AGRICULTURE SECTOR .....	281
10.5	LULUCF SECTOR .....	285
10.6	WASTE SECTOR .....	286
<b>11</b>	<b>KP-LULUCF .....</b>	<b>288</b>
11.1	GENERAL INFORMATION .....	288
11.2	LAND-RELATED INFORMATION .....	294
11.3	ACTIVITY-SPECIFIC INFORMATION .....	298
11.4	ARTICLE 3.3 .....	322
11.5	ARTICLE 3.4 .....	326
11.8	NIR TABLES .....	328
<b>12</b>	<b>INFORMATION ON ACCOUNTING OF KYOTO UNITS .....</b>	<b>330</b>
12.1	CALCULATION OF THE COMMITMENT PERIOD RESERVE (CPR) .....	332
12.2	KP-LULUCF ACCOUNTING .....	333
<b>13</b>	<b>INFORMATION ON CHANGES IN NATIONAL SYSTEM .....</b>	<b>333</b>
<b>14</b>	<b>INFORMATION ON CHANGES IN NATIONAL REGISTRY .....</b>	<b>333</b>
14.1	CHANGE IN CONTACT DETAILS OF THE REGISTRY ADMINISTRATOR .....	335
<b>15</b>	<b>INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14 .....</b>	<b>336</b>

## 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 an as 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<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>). 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 government decree. 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 (from 2012: Hungarian Energy Office), 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, Forestry Directorate) 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 1985-2010. 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 chapters following 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 2010, total emissions of greenhouse gases in Hungary were **67.7 million tonnes** carbon dioxide equivalents (excluding the LULUCF sector). After 2009, this is *the second lowest value* in the whole time series (1985-2010). Taking also into account the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 64.3 million tonnes CO<sub>2</sub> eq. in 2010. Being about 6-7 tonnes, the Hungarian per capita emissions are below the European average.

By ratifying the Kyoto Protocol, Hungary committed to reduce its GHG emissions by 6%. Now, our emissions are 41.0% 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 2010,

after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 14.9 per cent.

The global financial and economic crises exerted a major impact on the output of the Hungarian economy, consequently on the level of GHG emissions as well. Emissions (excluding LULUCF) decreased by 8.8% (-6.4 million tonnes) between 2008 and 2009. However, the decline in economic output stopped in the first quarter of 2010. Mainly driven by the growth in export-oriented industrial production, the GDP grew by 1.3% in 2010. GHG emissions changed quite similarly, as they increased by 1.2% above the 2009 level.

The most important greenhouse gas is carbon dioxide accounting for 75.9% of total GHG emissions. The main source of CO<sub>2</sub> emissions is burning of fossil fuels for energy purposes, including transport. CO<sub>2</sub> emissions have decreased by 39.5% since the middle of the 80's. Methane represents 12.5% in the GHG inventory. Methane is generated mainly at waste disposal sites and in animal farms, but the fugitive emissions of natural gas are also important sources. CH<sub>4</sub> emissions are 32.2% lower than in the base year. Nitrous oxide contributes 9.8% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N<sub>2</sub>O emissions are 60.8% lower compared to base year. The total emissions of fluorinated gases amount to 1.7%. Despite last year's fallback, F-gas emissions are showing a steadily growing tendency especially due to their applications in the cooling industry. SF<sub>6</sub> is mainly used in electrical equipments, first of all in switchgears for insulation and arc quenching. So, the growth of the electricity consumption results in an increasing application of SF<sub>6</sub>.

**Table ES. 1. Trend of emissions by GHGs**

<b>GREENHOUSE GAS EMISSIONS (CO<sub>2</sub>-eq, Gg)</b>	<b>Base year</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
<b>CO<sub>2</sub>, without LULUCF</b>	84 911.4	72 505.1	61 681.2	58 723.0	60 701.9	56 285.5	50 595.8	51 392.7
<b>CH<sub>4</sub>, without LULUCF</b>	12 504.2	11 748.8	9 501.7	9 692.7	8 989.8	8 608.5	8 452.9	8 478.8
<b>N<sub>2</sub>O, without LULUCF</b>	16 999.0	12 697.4	7 299.2	8 225.1	8 744.7	7 179.4	6 738.2	6 658.1
<b>HFCs</b>	0.0	NA.NO	0.7	223.1	602.7	940.3	855.0	914.3
<b>PFCs</b>	268.5	270.8	166.8	211.3	209.4	2.4	1.7	0.4
<b>SF<sub>6</sub></b>	73.1	87.6	169.6	195.3	237.7	275.5	220.6	234.9
<b>Total (excluding LULUCF)</b>	<b>114 756.1</b>	<b>97 309.7</b>	<b>78 819.2</b>	<b>77 270.4</b>	<b>79 486.2</b>	<b>73 291.7</b>	<b>66 864.2</b>	<b>67 679.1</b>

Base year=average of 1985-87

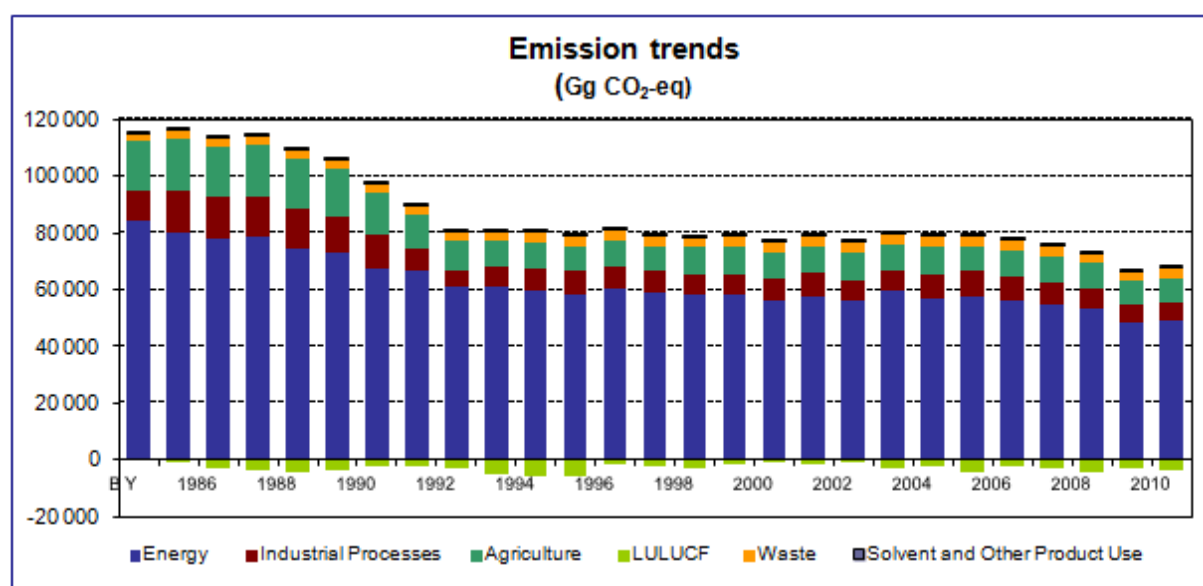
### ES.3. Overview of Source and Sink Category Emission Estimates and Trends

**Table ES. 2.** Trend of emissions (or removals) by emitting sectors

GREENHOUSE GAS EMISSIONS (CO <sub>2</sub> -eq, Gg)	Base year	1990	1995	2000	2005	2008	2009	2010
Energy	78 811.5	67 601.4	58 428.9	55 851.1	57 450.8	53 429.2	48 548.7	49 069.8
Industrial Processes	14 637.4	11 572.7	7 853.7	8 167.9	8 863.1	6 831.5	5 947.6	6 386.5
Solvent and Other Pr. Use	284.5	226.3	205.2	213.7	366.3	406.3	340.1	268.9
Agriculture	17 946.4	14 524.0	8 684.5	9 118.5	8 848.1	8 811.9	8 294.8	8 266.8
LULUCF	-2 171.1	-1 946.8	-5 801.1	-390.8	-4 413.0	-4 202.8	-3 316.4	-3 372.1
Waste	3 076.3	3 385.4	3 647.1	3 919.2	3 957.9	3 812.8	3 733.0	3 687.1
<b>Total (including LULUCF)</b>	<b>112 585.0</b>	<b>95 363.0</b>	<b>73 018.1</b>	<b>76 879.6</b>	<b>75 073.2</b>	<b>69 088.9</b>	<b>63 547.8</b>	<b>64 306.9</b>

Base year=average of 1985-87

By far, the biggest emitting sector was the energy sector contributing 72.5% to the total GHG emission in 2010. Agriculture was the second largest sector with 12.2% while emissions from industrial processes (with solvent and other product use) accounted for 9.8% and the waste sector contributed 5.4%. Compared to the base year, emissions were significantly reduced in the energy (-37.7%), agriculture (-53.9%), and industrial processes (-56.4%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+19.9%). 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 (1985-2010)

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

The **energy sector** was responsible for 72.5% of total GHG emissions in 2010. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 93.9% to sectoral emission. Considering fuel use in combustion processes, gases had the highest proportion (52.0%), liquids and solids represented 26.1% and 11.6%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 9.4%. The most important subsector was energy industries with a proportion of 34.0% within the energy sector, followed by other sectors (29.1%) and transport (24.2%). Fugitive emissions from fuels played only a small role with 4.6% out of which 70% originate from Natural Gas Production/Processing, Transmission and Distribution.

The significant reduction in emissions between 1987 and 1992 was mainly due to the economic transformation which caused sudden decrease in energy demand. In addition, ongoing changes in 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 increased by 1.1% or 0.5 million tonnes between 2009 and 2010. The growing energy demand of industry of 9% was the main driver of this increase. Besides, fuel consumption of public services, commerce, and domestic users was also higher than in 2009. Electricity production, where the GHG irrelevant nuclear production has a significant high share of more than 40%, also increased by about 4%. In contrast, after an increase of 88% between 1994 and 2008, transport emissions decreased in the second consecutive year, this time by 6.4%. This falling tendency is probably mainly due to the significantly higher fuel prices supported somewhat by the slightly growing biofuel use as well.

In 2010, **agriculture** was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH<sub>4</sub> and N<sub>2</sub>O gases: almost 85 percent of total N<sub>2</sub>O emissions were generated in agriculture in 2010. Emissions from agriculture decreased by 53.9% over the period of 1985-2010. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 15.6% to its present share of 12.2%.

Between 1996 and 2008, agricultural emissions stagnated around 9.1 Mt with fluctuations up to 5%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers increased by 68% until 2007 which caused growing nitrous-oxide emissions from agricultural soils. In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels.

Agricultural emissions decreased both in 2009 and 2010. A major reduction in emissions occurred in 2009, when emissions decreased by 6 per cent due to the lower N<sub>2</sub>O emissions from agricultural soils. The main reason for this is the lower fertilizer consumption. The continued decline in animal husbandry also contributed to the emission reduction. In 2009 the swine population reduced by 11 per cent, resulting lower CH<sub>4</sub> and N<sub>2</sub>O emissions levels from animal husbandry. Emissions from livestock had not changed considerably between 2009 and 2010. Although the fertilizer consumption was slightly higher in 2010 compared to 2009, there was a decline in the total agricultural emissions again due to the lower harvested production, thus the lower emissions levels from crop residues. Agricultural emissions in 2010 were the lowest in the whole time-series.

The **industrial processes** sector was the third largest sector, contributing 9.4% to total GHG emissions in 2010. (Solvent and other product use added further 0.4% to total emissions.) The most important greenhouse gas was CO<sub>2</sub>, contributing 81.2% to total sectoral GHG emissions, followed by F-gases with 18.0%. Within this sector, 35.2% of the emissions came from iron and steel industry, 22.1% from mineral products, followed by 18.0% from consumption of halocarbons and SF<sub>6</sub> and 16.6% from non-energy use of fuels. Process related industrial emissions decreased by 56.4% between base year and 2010, and by



27,9% between 2005 and 2010.

Although emissions of F-gases represent only 1.7% 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.

It has been the first year since 2005 when emissions increased again as GHG emissions from industrial processes sector were 7.4% (400 Gg) higher in 2010 than in 2009. There is still a decrease of 12,5% (202 Gg) of the emissions in category Mineral industry. Building industry is still struggling the recession (or stagnation) effecting of course building material producers, such as cement, glass, brick and tiles producers. Emissions from production of cement decreased by 24%, from glass production by 6%, and from brick and tiles production by 4%. However emissions have increased by 6.7% from consumption of halocarbons and SF<sub>6</sub>, 9.1% in chemical industry, 18.2% in metal production and 20.4% by non-energy use of fuels compared to the previous year.

The **waste** sector represented 5.4% of total national GHG emissions in 2010. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+19.9%). However, the growth of emissions stopped in recent years, moreover a reduction of 6.8% could be observed between 2005 and 2010. In all the years, the largest category was solid waste disposal on land, representing 79.9% in 2010, followed by wastewater handling (17.7%) and waste incineration (2.4%). Although degradation process takes many years after disposal, the amount of disposed waste had decreased significantly, by almost 30%, since 2005 which led to lower methane emissions. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

In the **Land Use Land-Use Change and Forestry** sector, using the currently available data, carbon uptake of the forests living biomass, non-CO<sub>2</sub> 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. The complex dynamics of the land use and land-use changes leads to highly fluctuating estimates of sectoral removals. Our estimates indicate an average annual 2.9 million tonnes removal, CO<sub>2</sub>-eq. net removals range from 0.07 million tonnes in 1985 to 5.8 million tonnes CO<sub>2</sub> in 1995. In 2010 the LULUCF sector accounted for 3.4 million tonnes carbon-dioxide removals. The removals of forests amounted to 3.1 million tonnes, while the living biomass of orchards and vineyards were a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. The emission of the living biomass of vineyards and orchards accounted for 0.34 million tonnes CO<sub>2</sub> in 2010.

Our mineral soils in croplands remove a small amount of carbon (0.92 Mt in 2010), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favourable processes that increase the soil carbon content.

As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.2 million tonnes CO<sub>2</sub>-eq. mainly due to afforestation and reforestation in 2010. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 1.7 million tonnes CO<sub>2</sub>-eq.

## ES.4. Indirect Greenhouse Gases and SO<sub>2</sub>

NO<sub>x</sub>, CO and NMVOC gases are referred to as indirect gases because they (together with SO<sub>2</sub>) 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.

The following table shows the main trends in emissions:

**Table ES 3. Emissions of indirect gases.**

Indirect gases	1985	1990	2000	2003	2005	2006	2007	2008	2009	2010
<b>NO<sub>x</sub>, Gg</b>	262.5	238.0	185.1	210.8	203.2	202.5	185.5	169.1	154.5	<b>152.5</b>
<b>CO, Gg</b>	931.1	997.0	558.8	566.3	554.9	561.0	542.1	538.4	527.0	<b>533.5</b>
<b>NMVOC, Gg</b>	232.0	205.0	159.1	167.9	170.0	178.0	156.9	157.2	121.8	<b>109.9</b>
<b>SO<sub>2</sub>, Gg</b>	1403.6	1010.0	488.9	347.8	147.8	123.1	98.6	105.6	89.4	<b>36.9</b>

*The database is not complete for the 80's.*

The substantial reduction in sulphur dioxide emissions (-95%) is attributable to the decreased use of fossil fuels in general and the decreasing share of coal with higher sulphur content. After 2000, further reductions were observed due to the introduction of SO<sub>2</sub> precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. The decrease in NO<sub>x</sub> emissions is relatively moderate due to the increasing significance of transport.

# 1 INTRODUCTION

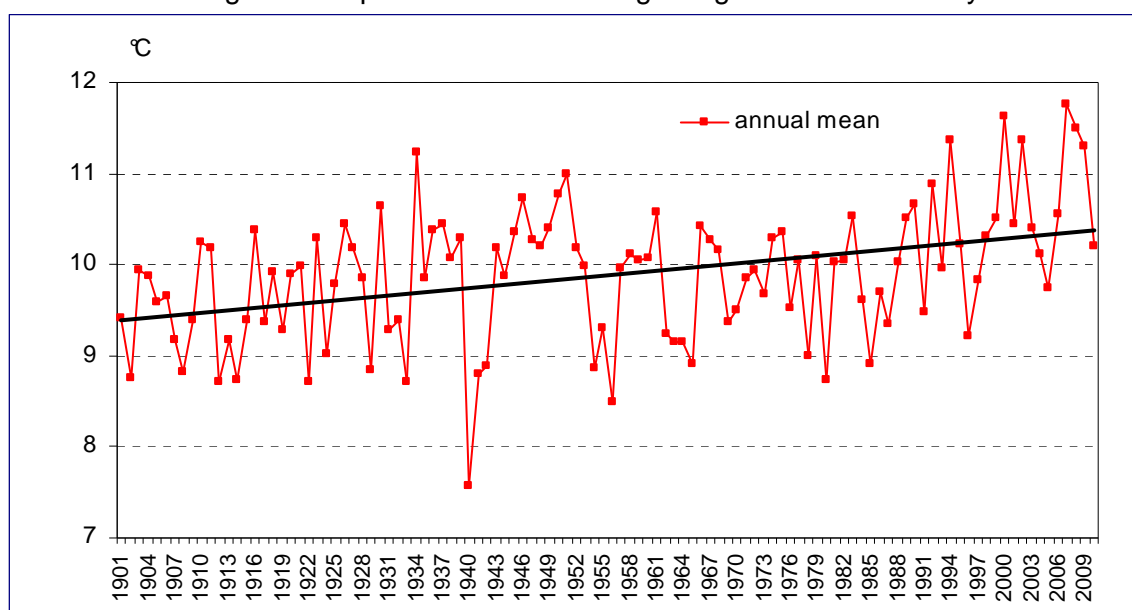
## 1.1 Background information and climate change

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<sub>2</sub> equivalent.

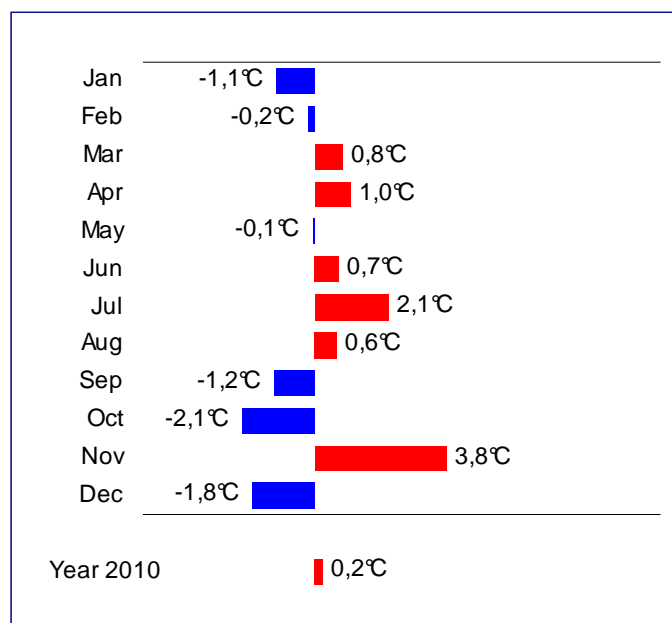
The regional effects of the global climate change can clearly be seen on the Hungarian observations. The annual averages of temperature in Hungary are very similar to the well-known wave of the global temperature since the beginning of the 20th century.



**Figure 1.1.** Annual mean temperature (°C) in the period 1901-2010 in Hungary

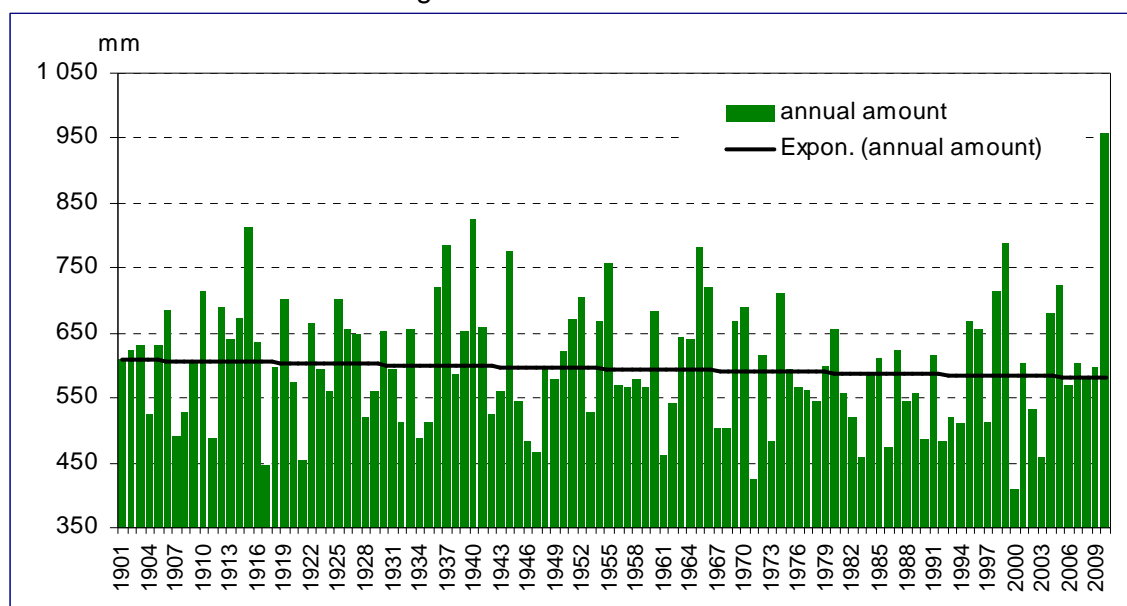
Although in 2010 we had a close to average yearly mean temperature, we could observe a rise of 0.98°C in the last 110 years. Considering the last 30 years, the temperature increase

is even more pronounced with  $+1.17^{\circ}\text{C}$  based on the homogenized, interpolated dataset of the Hungarian Meteorological Service (Fig. 1.1). Looking at monthly temperatures, 5 months showed negative and 7 months positive anomalies (Fig. 1.2). Altogether, 2010 wasn't an exceptional year in Hungary. In contrast, as the World Meteorological Organization reported, average global temperatures were estimated to be  $0.53^{\circ}\text{C} \pm 0.09^{\circ}\text{C}$  above the 1961–1990 annual average of  $14^{\circ}\text{C}$ . This makes 2010 tied for warmest year on record in records dating back to 1880.

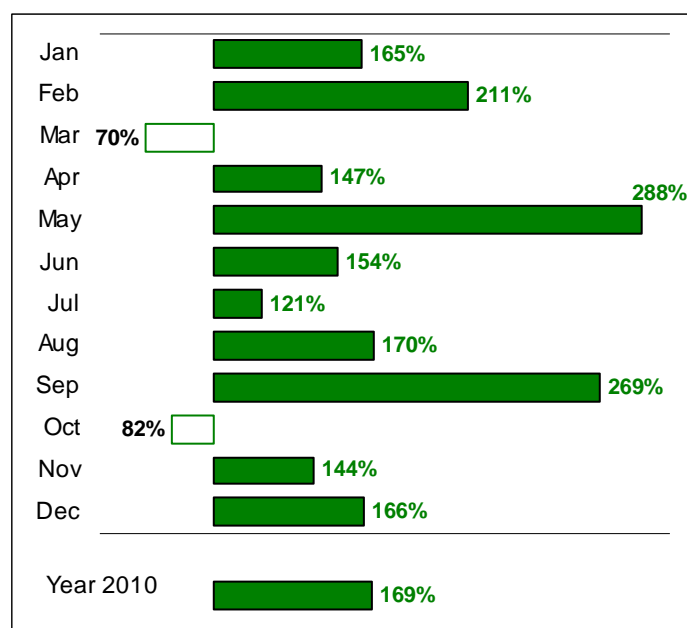


**Figure 1.2.** Anomalies (compared to 1971-2000 mean) of the countrywide monthly mean temperatures in 2010 in Hungary ( $^{\circ}\text{C}$ )

The yearly total precipitation in 2010 (959 mm) was the highest ever recorded and it was more than 130 mm above the second highest value from 1940. The exponential trend fitted to the 110 year-long data series shows moderate declining (Fig. 1.3.), Monthly amounts and anomalies are summarized in Fig 1.4.



**Figure 1.3.** Annual precipitation sum (mm) in the period 1901-2010 in Hungary



**Figure 1.4.** Monthly precipitation averages (%) in 2010 compared to the reference period (1971-2000 mean) in Hungary

## 1.2 Institutional arrangements

The minister responsible for the environment 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. Since the Ministry of Environment and Water had been abolished after the elections in spring 2010, and its tasks have been taken over by the Ministry of Rural Development, the designated *single national entity* is now the Ministry of Rural Development. As a new feature, the national system has to be operated by the minister responsible for the environment like earlier but, as prescribed by legislation, in consent and cooperation with the ministers responsible for energy policy and forest management. Within the Ministry of National Development, i.e. the ministry responsible for energy policy, a Climate Policy Department has been established that plays some coordinating and supervisory role in the national system. The head of this department is Hungary's current UNFCCC Focal Point.

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.

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 designation of the Hungarian Meteorological Service as the compiler institute. As a new element, the participation of the Forestry Directorate of the Central Agricultural Office (CAO, Forestry Directorate) 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 Rural Development. 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 functions as part of the Climate and Atmospheric Environment Department.

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 agriculture and LULUCF (except forestry) sector are compiled by the HMS with contribution of external experts / institutions on contractual basis as follows. The forestry related parts are compiled by the Central Agricultural Office and the Forest Research Institute as prescribed by government decree. For the calculation of emissions from agricultural soils Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) was contracted like in the last three years. The Research Institute for Animal Breeding and Nutrition has been heavily involved in the calculations for the agriculture sector of the inventory for several years. The following table summarizes the institutional arrangements:

<i><b>Function</b></i>	<i><b>Institution</b></i>	<i><b>Responsibilities</b></i>
Single national entity	Ministry of Rural Development (in consent and cooperation with Ministry of National Development)	<ul style="list-style-type: none"> <li>• Supervision of national system</li> <li>• Official consideration and approval of inventory</li> </ul>
Inventory coordination and compilation	OMSZ GHG division	<ul style="list-style-type: none"> <li>• Provision of work plan</li> <li>• Contracting consultants</li> <li>• Inventory preparation of Energy, Industry and Waste sector</li> <li>• Completion of CRF and NIR</li> <li>• Archiving</li> <li>• Coordinating QA/QC activities</li> <li>• Reporting to UNFCCC secretariat</li> </ul>
Inventory preparation of Forestry and LULUCF activities under the KP. (by law)	Central Agricultural Office (CAO, Forestry Directorate) Forest Research Institute	<ul style="list-style-type: none"> <li>• Data collection, choice of methods and EFs, inventory preparation</li> </ul>
Contribution to the inventory preparation of Agriculture sector	Research Institute for Animal Breeding and Nutrition	<ul style="list-style-type: none"> <li>• Data collection, choice of method, development of country specific emission factors</li> <li>• Background studies</li> </ul>

<i>Function</i>	<i>Institution</i>	<i>Responsibilities</i>
Agricultural soils	Karcag Research Institute of University of Debrecen	• Data collection, choice of methods and EFs, background research and studies

### 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:  $AD \times EF$ , 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.

The inventory cycle can be summarized with the following table based on our QA/QC plan:

<i>Date/deadline</i>	<i>Item</i>	<i>To</i>
From May to November	Overview of sectors to identify areas for possible improvements; Data collection, choice of methodologies, Start of calculations Repeated checks	
30 November	Calculations from external expert	
15 December	Calculations, checks, archiving	
08 January	Main features for National Inventory Report (CRF tables and part of NIR) for approval	National Authority
15 January	Official submission	EU
Between January and March	QC procedures including EU internal review	
08 March	National Inventory Report final version for approval	National Authority
15 March	National Inventory Report, Official submission	EU
Between March and April	QC procedures in the process of finalizing the NIR and CRF tables	
08 April	National Inventory Report for approval	National Authority



<i>Date/deadline</i>	<i>Item</i>	<i>To</i>
15 April	Official submission	UNFCCC
30 April	Archiving	internal
15 October	QA/QC and Development Plan	internal

As already discussed above, the two main compiler institutes are: (1) Hungarian Meteorological Service (HMS) and (2) Central Agricultural Office, the latter is responsible for the forestry part of the inventory.

The Met. Service, where an inventory team is located, is authorized by law to collect the necessary data. Calculations are either carried out by us or by external experts on contractual basis. The inventory report is approved by two ministers: (1) minister for national development approves before official submission to the EU, (2) minister for rural development approves before submission to the UNFCCC.

## 1.4 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 and the Hungarian Electrotechnical Association.

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 of Rural Development 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.
- Hungarian Statistics on Road Vehicles (in electronic format since 2000)
- 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:

- Data from individual industrial plants – Ministry of Rural Development
- 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 + Ministry of Rural Development.

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.

HMS's general record management regulation has been amended in 2011. The new regulation had been supplemented with a new chapter relating to the Greenhouse Gas Division. The main elements of the former proposal of the 'manual for the maintenance and management of the archiving system' as the procedures of documents and data handling had been formalized in this regulation.

The particular issue of this regulation is to ensure the integrity and confidentiality of the data handling relating to the GHG inventory. The regulation has specific rules on handling confidential data as well. These rules are as follows:

Confidential data are

- accessible only for members of the GHG Division. They are not allowed to be forwarded to other institute or persons, except for the ERT
- it is not allowed to make hard copies of these documents, only one electronic copy can be made, which is stored on the server of the GHG division;
- data stored on the server of GHG are protected by password;
- it is not allowed to take out any confidential information from the Met. Service, not even their copies;
- the original hard copies are not allowed to be forwarded to the Hungarian Environmental Archives, they are stored in the records of the HMS's GHG Division.

The new regulation has been endorsed by the Minister of Public Administration and Justice and has been in force since January of 2012.

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.

## 1.5 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:

$$\text{Emission} = \text{AD} \times \text{EF},$$

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 CO<sub>2</sub> / TJ and 108.3 t CO<sub>2</sub> / 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 criteria 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.

## 1.6 Key source categories

Key source category analysis followed the practice of the last year. For TIER1 methodology the aggregation level of source categories suggested by GPG2000 and GPG2003(for LULUCF) was used adding the missing sectors significant in Hungary and aggregating some sectors. In this way the sectors assessed cover the TOTAL emissions (with LULUCF). This means a slight modification compared to the last year: aggregation and renaming of a few sectors and a new format is used for better understanding. This is the aggregation level of source categories which is used also in CRF Table 7. In this way the recommendation of the last year review is fulfilled, as the list of source categories presented in the NIR and in CRF are the same. Solely for additional information the key category analysis is still performed on a list of more disaggregated source categories, presented in Annex 1

In this year uncertainty values for LULUCF sector become available, so a key category analysis using TIER2 methodology was also performed on the above mentioned complete list of source categories. . In this year the threshold of Key source categories are changed to 90% as it is suggested in GPG2000 Chapter 7.2.1. The required uncertainty values for TIER2 Key category analysis methodology were determined using TIER1 uncertainty analysis on the basis of the GPG2000 and GPG 2003, but estimates of data supplier institutions and experts were used as well.

Both LEVEL and TREND assessment was made with both methodology. The changes in TIER1 Key source categories are the following:

- Trend in 2. A. 1.- CO<sub>2</sub> Emissions from Cement Production turned up first time this year reflecting the recession of cement production in Hungary.
- Trend and Level in 2.C – CO<sub>2</sub> emission from Metal Processes, which is due to the reallocation of emissions connected to Iron and steel industry between Energy and Industrial Processes sectors.
- Trend in sector 2. F. - Emissions from HFCs consumption, which is one of the most significantly growing sector, but last year did not turn up due to a mistype error.
- Trend in 5. B. 1.Cropland Remaining Cropland, which is due to the significant recalculation of this year.
- Level and trend in 5.A.2. Land converted Forest Land, which is due to the significant recalculation of this year.

Three sectors identified as key category of last year by level and/or trend assessment are just very near, but under the threshold this year:

- 5.B. LULUCF Cropland converted to - CO<sub>2</sub>
- 1. A. 3. Mobile Combustion – Other - CO<sub>2</sub>
- 1. A. 3. Mobile Combustion - N<sub>2</sub>O
- 1. A. Non-CO<sub>2</sub> Emission from Stationary Fuel Combustion - CH<sub>4</sub>2.A.2 Lime production - CO<sub>2</sub>
- 2.A.3 Limestone and dolomite use - CO<sub>2</sub>
- 2.A.7 Other Mineral production - CO<sub>2</sub>

The changes in Key source categories identified with TIER2 methodology are due to the change of threshold, correction of a mistype error in the case of sector 2.F and inclusion of LULUCF sectors

*Table 1.1. Number of identified Key categories using different methodologies*

	<b>TIER1</b> (without uncertainties, including LULUCF)	<b>TIER2</b> (with uncertainties, including LULUCF)
<b>LEVEL</b>	22	14
<b>TREND</b>	24	17

It is worth mentioning that categories identified by trend assessments include categories with inclining and declining emission too, as it is stated in the guidelines „In this analysis the

negative and positive values are considered equivalent, and the absolute values of these are recorded in the table.” (GPG2000 7.2.1.1 Footnote 5) However declining emission trends are noted (-) in Table 1.2

*Table 1.2. Key category analysis summary*

IPCC Category Code	IPCC category name	GHG	Method	Note on aggregation level
1. A.	Stationary Combustion – Coal	CO <sub>2</sub>	L1, T1 (-), L2, T2	
1. A.	Stationary Combustion – Gas	CO <sub>2</sub>	L1, T1, L2, T2	
1. A.	Stationary Combustion - Oil	CO <sub>2</sub>	L1, T1 (-), T2	
1. A.	Stationary Combustion - Other Fuel	CO <sub>2</sub>	L1, T1	
1. A. 3.	Mobile Combustion	N <sub>2</sub> O	T1, L2, T2	HU specific- aggregated from all subcategories in 1.A.3.
1. A. 3. B.	Mobile Combustion - Road	CO <sub>2</sub>	L1, T1, L2, T2	
1. B. 1.	Fugitive Emissions from Coal Mining and Handling	CH <sub>4</sub>	T1(-)	
1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH <sub>4</sub>	L1, T1, L2, T2	
2.	N <sub>2</sub> O Emission from Industry	N <sub>2</sub> O	T1(-)	HU specific- aggregated from all subcategories in sector 2 (including Nitric Acid production)
2. A. 1.	CO <sub>2</sub> Emissions from Cement Production	CO <sub>2</sub>	L1, T1(-)	
2. A. 7.	CO <sub>2</sub> Emission from Other Mineral Products	CO <sub>2</sub>	T1(-)	HU specific- addition to the list of suggested IPCC source categories
2. B. 1.	CO <sub>2</sub> Emissions from Ammonia Processes	CO <sub>2</sub>	L1, T1(-)	HU specific - addition to the list of suggested IPCC source categories
2.C	CO <sub>2</sub> Emissions from Metal Processes	CO <sub>2</sub>	L1, T1(-)	
2.	All HFC emissions	HFCs	L1, T1, T2	HU specific - aggregation
2.	All SF <sub>6</sub> emissions	SF <sub>6</sub>	T2	HU specific - aggregation
2. G.	Feedstocks and non-energy use	CO <sub>2</sub>	L1, T1	HU specific - addition to the list of suggested IPCC source categories
4. A.	CH <sub>4</sub> Emissions from Enteric Fermentation in Domestic Livestock	CH <sub>4</sub>	L1, T1(-)	
4. B.	CH <sub>4</sub> Emissions from Manure Management	CH <sub>4</sub>	L1, T1(-)	
4. B.	N <sub>2</sub> O Emissions from Manure Management	N <sub>2</sub> O	L1, T1(-), L2, T2	

IPCC Category Code	IPCC category name	GHG	Method	Note on aggregation level
4. D. 1.	Direct N <sub>2</sub> O Emissions from Agricultural Soils	N <sub>2</sub> O	L1,T1(-) L2, T2	
4. D. 3.	Indirect N <sub>2</sub> O Emissions from Nitrogen Used in Agriculture	N <sub>2</sub> O	L1, T1(-) L2, T2	
5. A. 1.	Forest Land Remaining Forest Land	CO <sub>2</sub>	L1, T1, L2	
5. A. 2.	Land converted Forest Land	CO <sub>2</sub>	L1, T1,L2,T2	
5. B. 1.	Cropland Remaining Cropland	CO <sub>2</sub>	L1, T1,L2,T2	
5. C. 1.	Grassland Remaining Grassland	CO <sub>2</sub>	L1, T1,T2	
5.C.2	Land converted to Grassland	CO <sub>2</sub>	T2	
6. A.	CH <sub>4</sub> Emissions from Solid Waste Disposal Sites	CH <sub>4</sub>	L1, T1, L2,T2	
6. B.	Emissions from Wastewater Handling	CH <sub>4</sub>	L1	
6. B.	Emissions from Wastewater Handling	N <sub>2</sub> O	L2, T2	

Notation key:

L1= Level Assessment using TIER1 methodology

T1=Trend Assessment using TIER1 methodology

L2=Level Assessment using TIER2 methodology

T2= Trend Assessment using TIER2 methodology

More detailed description on Key category analysis can be found in Annex I.

## 1.7 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 2012 during which the activities of the GHG Division were also audited
  - There is an ongoing QA procedure between the two institutes involved in the forestry part of the inventory. Peer-reviews will be conducted depending on available resources
  - The recommendations of the last years' in-country review conducted by the expert review team of the UNFCCC will be taken into consideration as much as possible (see Annex 8.)
- Checking the results of the EU's internal review for the EU15, and analyze its relevance for Hungary.
- In 2012 the EU will carry out comprehensive individual technical reviews concentrating on the years 2005, 2008, 2009 and 2010.
- 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.
- Comprehensive consistency check between national energy statistics and IEA time series.
- 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 2012. 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. As a new element, experts involved in emission forecast consulted in many areas with inventory experts of the Hungarian Meteorological Service to reach better consistency, which in turn represented some sort of QA procedure for the inventory itself.

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



## 1.8 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<sub>2</sub> emissions and the least reliable ones are those of N<sub>2</sub>O emissions.

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

The CO<sub>2</sub> calculation has the highest reliability and has a weight of 74.6% in the total emission (in CO<sub>2</sub>-eq including LULUCF). The least reliable is N<sub>2</sub>O calculation representing 10.4% (in CO<sub>2</sub>-eq including LULUCF). CH<sub>4</sub>, which has a medium reliability, has a similar proportion (13.2% in CO<sub>2</sub>-eq including LULUCF). Fluoride gases are irrelevant here because their contribution to the total emission is only 1.8% (in CO<sub>2</sub>-eq including LULUCF). Accordingly, the calculated uncertainties of the emissions of different gases are as follows (more details in *Table A7-2* in the Annexes):

CO <sub>2</sub>	4.9%
CH <sub>4</sub>	17.2%
N <sub>2</sub> O	132.9%

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 2010) is 18.18% and the uncertainty introduced in trend in national emissions is 3.03%.

It was noted during the review of last year that the combined total uncertainty estimate was higher than the years before. The reason is the increase of uncertainty in the Agricultural sector (N<sub>2</sub>O) detailed in chapter 6.1.6..

## 1.9 Completeness

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2009. 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. More information can be found in Annex 5.

## 2 TRENDS IN GREENHOUSE GAS EMISSIONS

In the United Nations Framework Convention on Climate Changes, Hungary undertook to keep its CO<sub>2</sub> emissions in 2000 at or below the 1990 level. In the Kyoto Protocol, our country committed to reduce the average greenhouse gas emission by 6% of the base year level during the five years of the first commitment period (2008 to 2012). It will be shown in the next Sections that Hungary has complied with these commitments.

### 2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

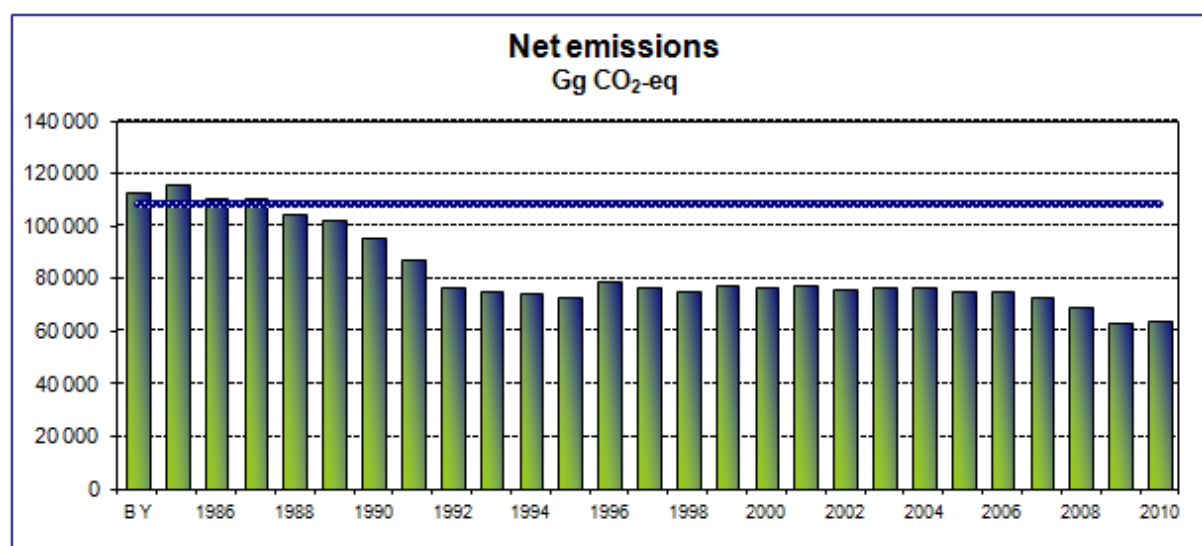
The trends of the total greenhouse gas emissions may be assessed on the basis of the GWP. The table below shows the time series of net and gross emissions:

*Table 2.1. Total GHG emissions (including and excluding LULUCF)*

GREENHOUSE GAS EMISSIONS (CO <sub>2</sub> -eq, Gg)	BY fixed	1990	1995	2000	2005	2008	2009	2010
Total (including LULUCF)	112 661	95 363	73 018	76 880	75 073	69 089	63 548	64 307
Total (excluding LULUCF)	115 397	97 310	78 819	77 270	79 486	73 292	66 864	67 679

*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.



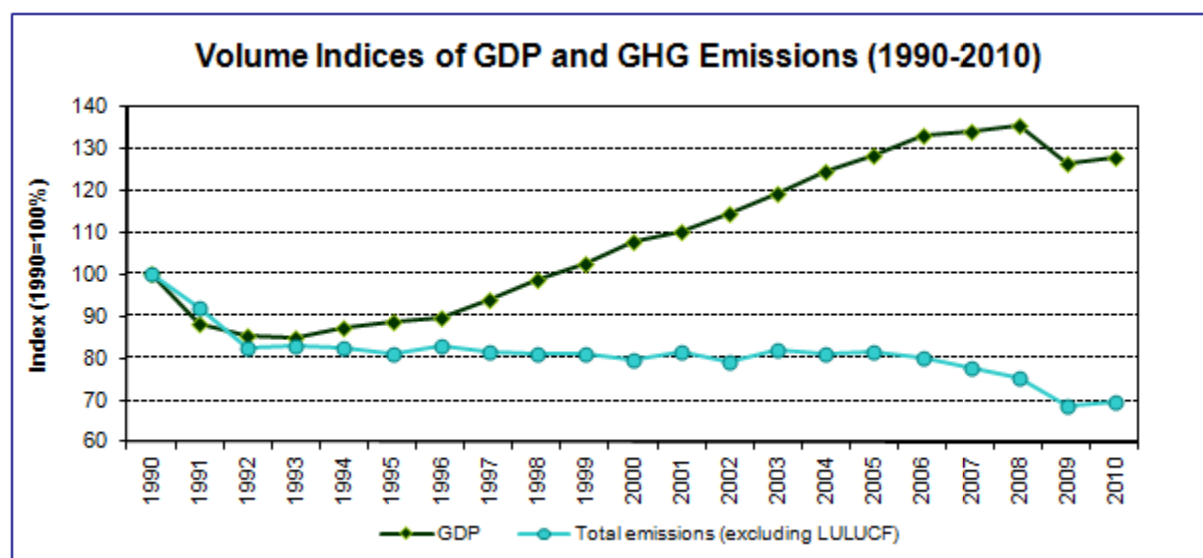
*Figure 2.1. Total emission (including net CO<sub>2</sub> from LULUCF) between 1985 and 2010*

Compared to the base year, emissions were significantly reduced in the energy (-37.8%), agriculture (-54.0%), and industrial processes (-60.9%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+24.4%). 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

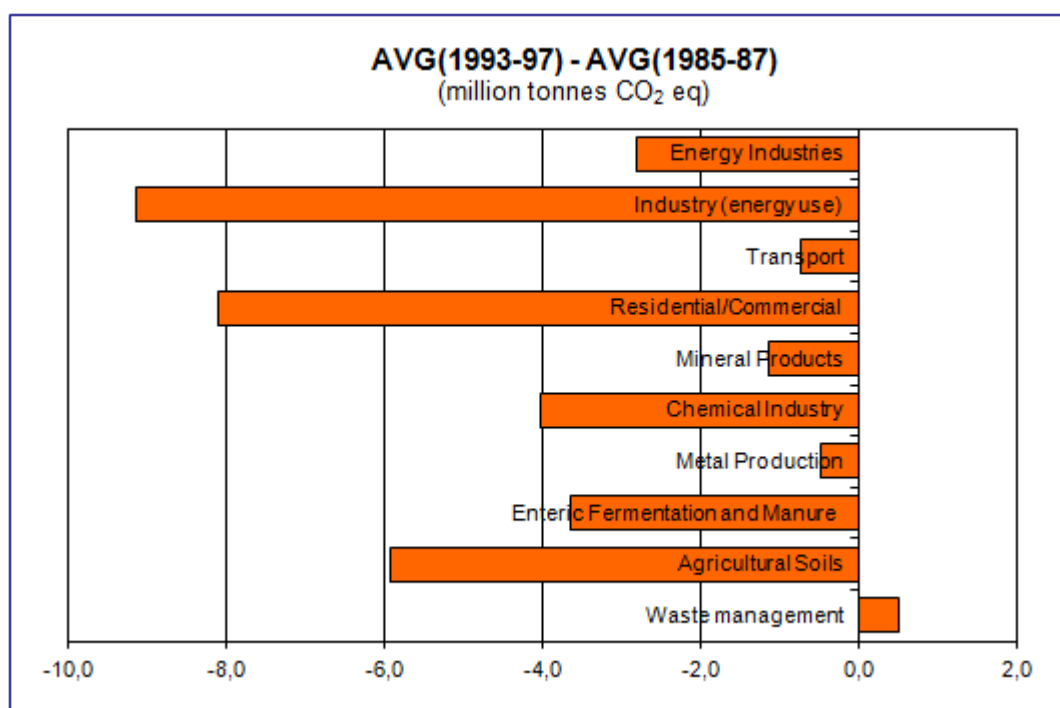
In the third period, after 2005, Hungary experienced an emission reduction of about 15%, half of it in the first 2-3 years up to 2008: basically due to mild winters, higher energy prices, and modernization in the chemical industry. Then in 2009, the global financial-economic crisis made its radical influence felt which can also be seen at the dropping GDP values in Fig. 2.2. In 2010 a slight recovery of the economy could be observed.

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<sub>2</sub> 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:

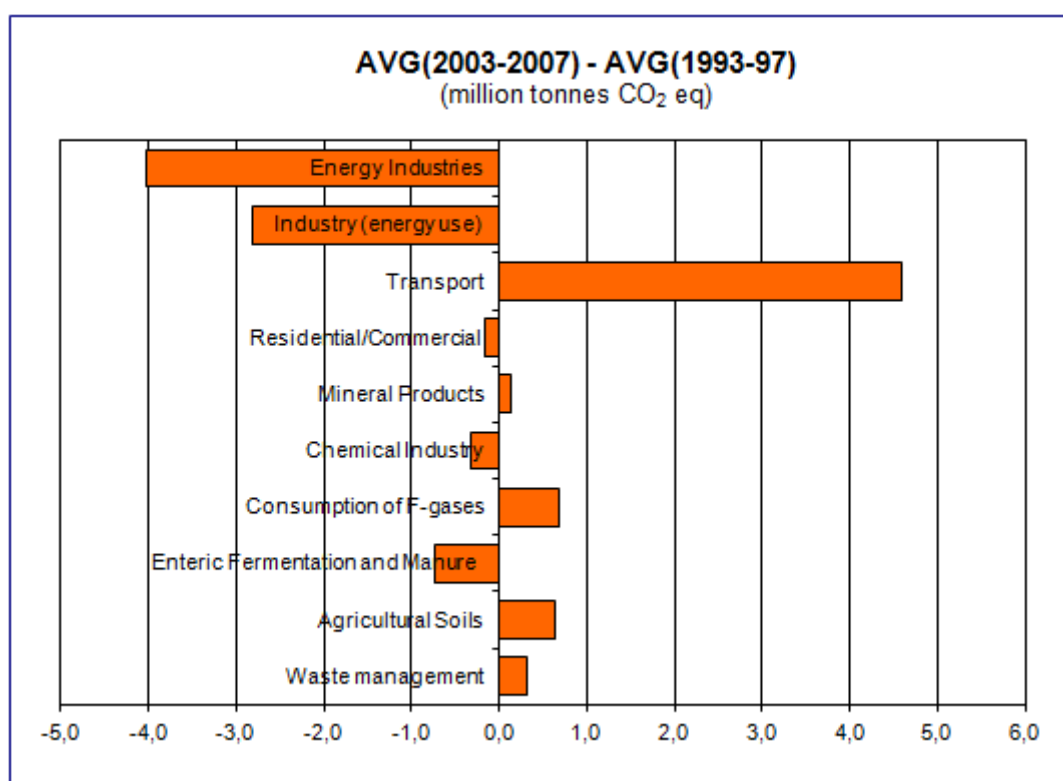
- Iron and steel production: two out of three plants were provisionally closed down;
- Aluminium: two out of three plants were closed down in 1991 (aluminium production stopped in 2006 eventually);
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 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 15.7% to 12.5%.



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

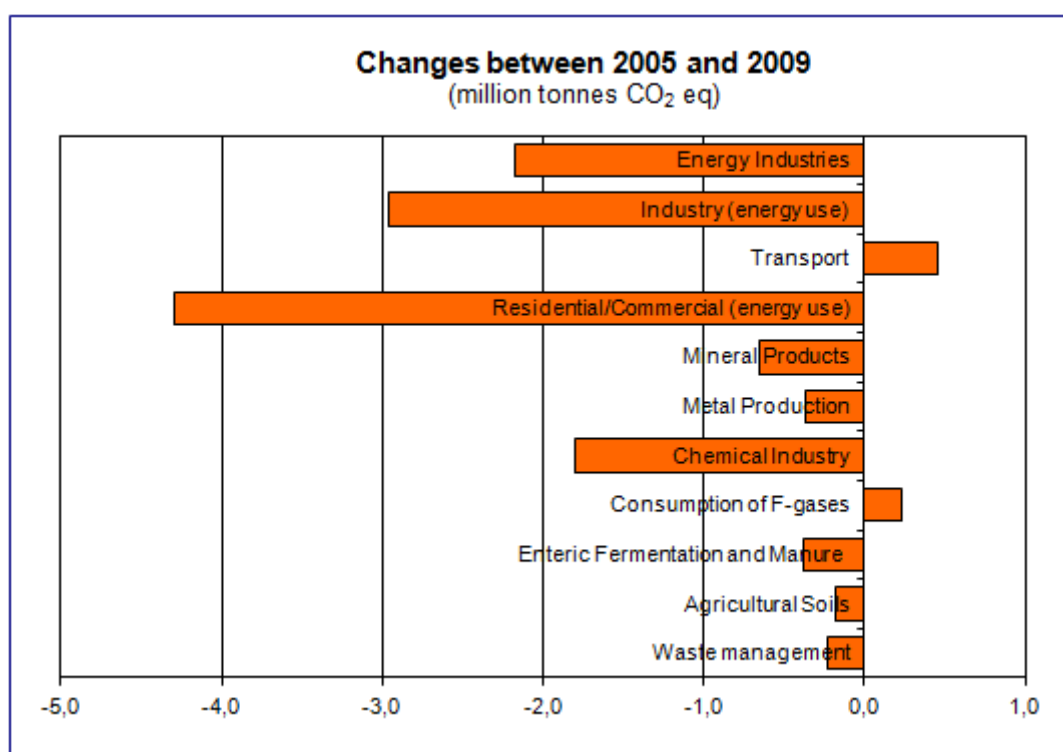
The small increase of emissions in the *Waste* sector is exceptional among all the sectors, and it is attributable to the slightly increasing quantities of waste generated and collected but more importantly to the applied calculation method which assumes that the degradable organic component in waste decays slowly throughout a few decades.



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

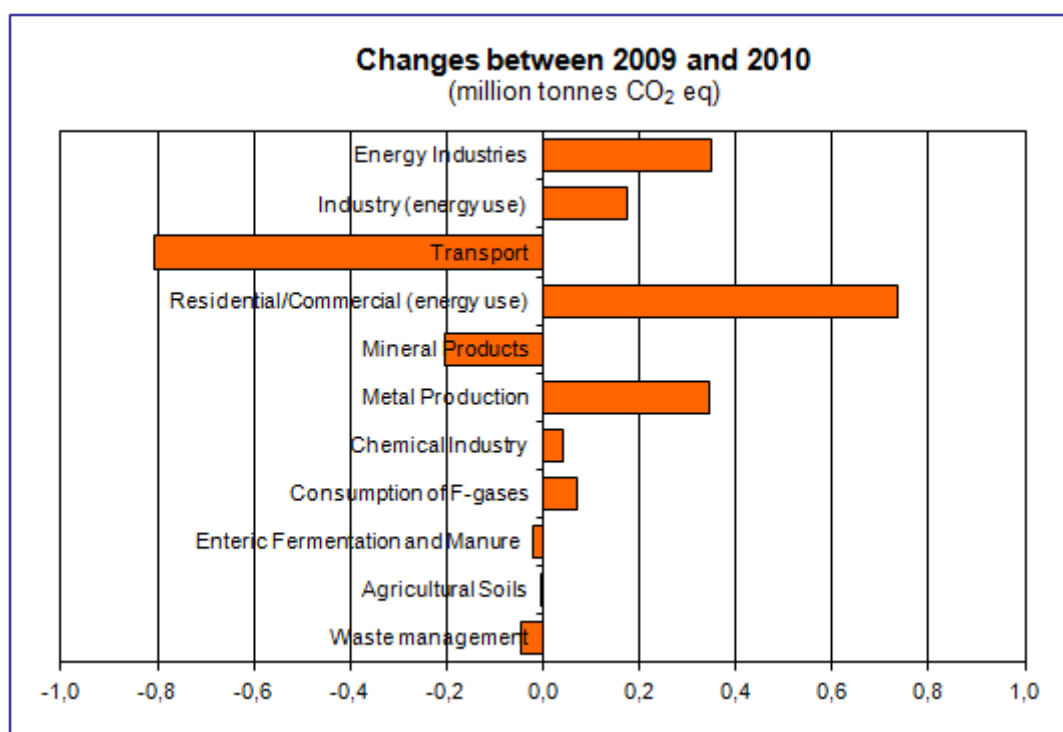
After the mid 90's, emissions seemed to have been stabilized around 79-80 million tonnes CO<sub>2</sub> equivalent. However, behind the quite stable emission level opposite processes could be observed which can be illustrated by the relatively bigger changes in the *energy sector*. The fuel use of industry decreased further and had only a 15% share in CO<sub>2</sub> emissions. In contrast, emissions from transport increased significantly by more than 4 million tonnes CO<sub>2</sub> equivalent which represented a more than 60% growth.

In the third period, after 2005, emissions fell by 11.8 million tonnes or 14.9%. About half of this decrease occurred between 2005 and 2008. 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 about 80%. In contrast, emissions from energy industries and transport grew further. Then in 2009, the Hungarian economy was hit hard by the global economic crisis that exerted a significant effect on the emission level. Emissions (excluding LULUCF) decreased by 8.8% (-6.4 million tonnes) between 2008 and 2009. In comparison with 2008, emissions in 2009 were lower in all major sectors. The highest relative reduction (-12.9%) occurred in the industrial processes sector mainly due to lower production volumes especially in mineral product manufacturing (-28.9%). Regarding absolute changes in emissions, out of the 6.4 million tonnes reduction, fuel combustion was responsible for about 4.9 million tonnes. Although the energy demand increased in the heating season due to less favorable weather conditions, the fall in the production of energy intensive sectors led to an overall decline in energy use.



**Figure 2.5.** Changes in emissions between 2005 and 2009

The decline in economic output stopped in the first quarter of 2010. Mainly driven by the growth in export-oriented industrial production, the GDP grew by 1.3% in 2010. GHG emissions changed quite similarly, as they increased by 1.2% above the 2009 level.



**Figure 2.6.** Changes in emissions between 2009 and 2010

However, it is worth mentioning the quite significant decrease of transport emissions between 2009 and 2010 which was most probably due to the increasing fuel prices.

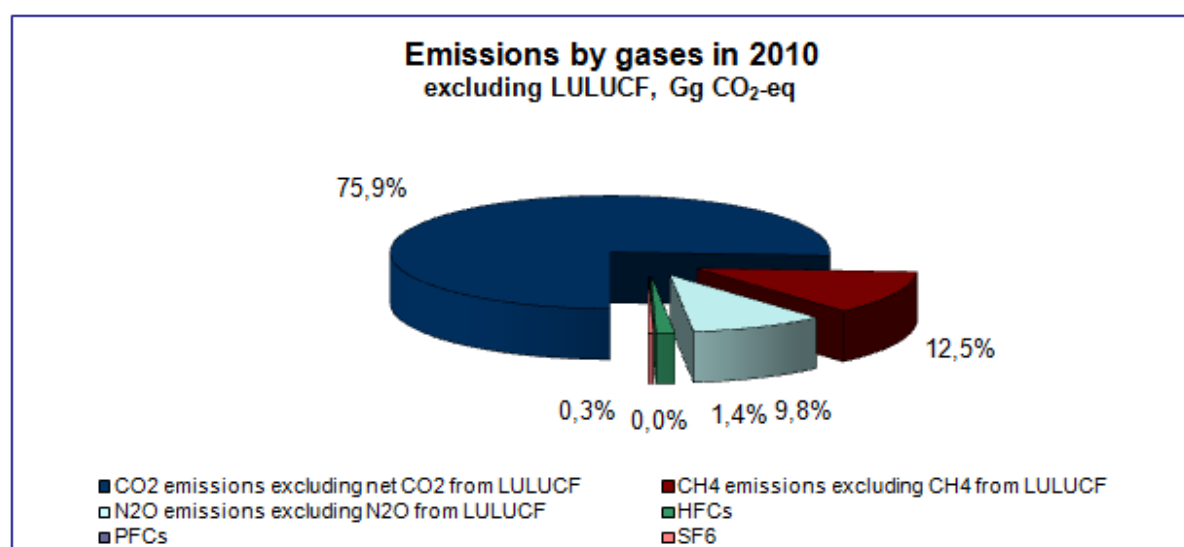
## 2.2 Description and interpretation of emission trends by gas

The following table shows the emission data for each greenhouse gas (Gg CO<sub>2</sub> equivalent):

**Table 2.2.** Trends in emissions of greenhouse gases in Hungary (1985-2010)

GREENHOUSE GAS EMISSIONS (CO <sub>2</sub> -eq, Gg)	Base year	1990	1995	2000	2005	2008	2009	2010
CO <sub>2</sub> , without LULUCF	84 911.4	72 505.1	61 681.2	58 723.0	60 701.9	56 285.5	50 595.8	51 392.7
CH <sub>4</sub> , without LULUCF	12 504.2	11 748.8	9 501.7	9 692.7	8 989.8	8 608.5	8 452.9	8 478.8
N <sub>2</sub> O, without LULUCF	16 999.0	12 697.4	7 299.2	8 225.1	8 744.7	7 179.4	6 738.2	6 658.1
HFCs	0.0	NA.NO	0.7	223.1	602.7	940.3	855.0	914.3
PFCs	268.5	270.8	166.8	211.3	209.4	2.4	1.7	0.4
SF <sub>6</sub>	73.1	87.6	169.6	195.3	237.7	275.5	220.6	234.9
<b>Total (excluding LULUCF)</b>	<b>114 756.1</b>	<b>97 309.7</b>	<b>78 819.2</b>	<b>77 270.4</b>	<b>79 486.2</b>	<b>73 291.7</b>	<b>66 864.2</b>	<b>67 679.1</b>

Base year=average of 1985-87

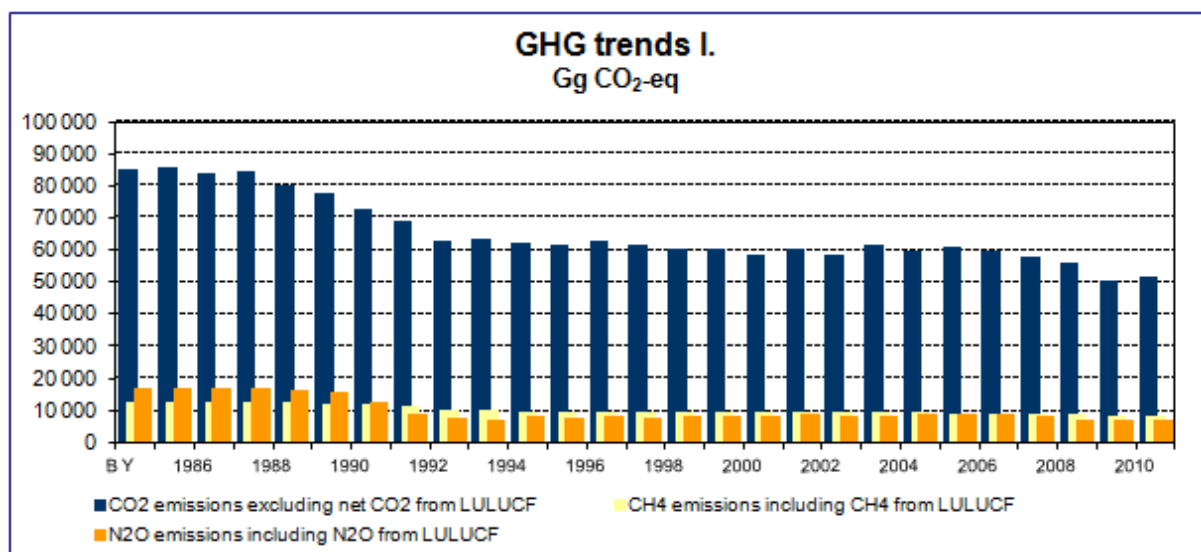


**Figure 2.7.** Shares of emissions of greenhouse gases in 2010

The drop in CO<sub>2</sub> 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<sub>4</sub> emissions, agriculture, fugitive emissions, and waste management are the trend setting sectors. Most importantly, 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 had 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<sub>2</sub>O 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.

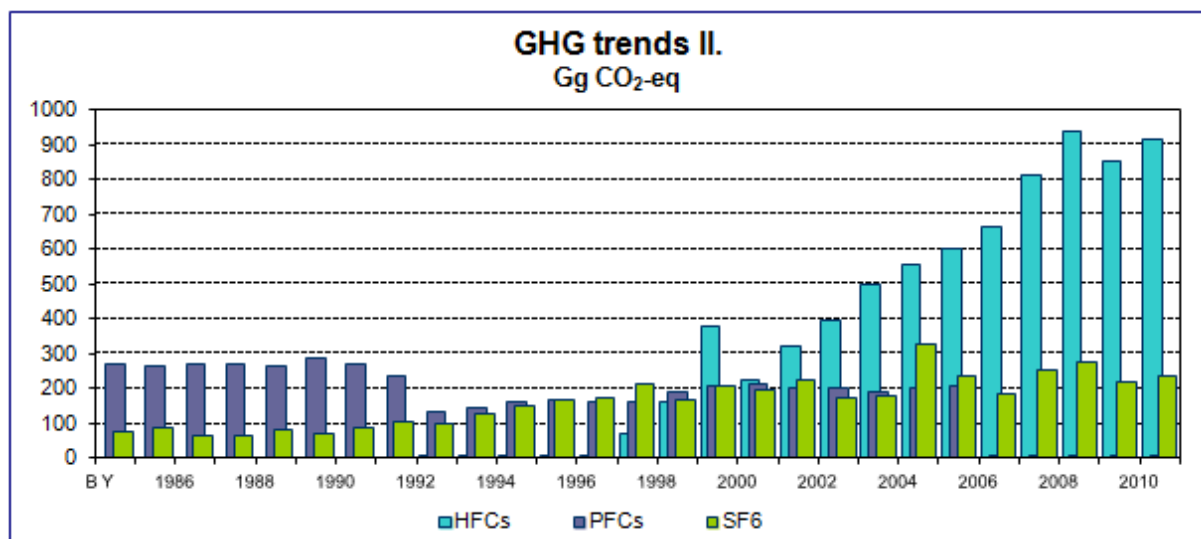


**Figure 2.8. Trend of emissions by gases**  
Note: BY=average of 1985-87 but 1995 for F-gases

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, even if there was a decrease in 2009.

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.

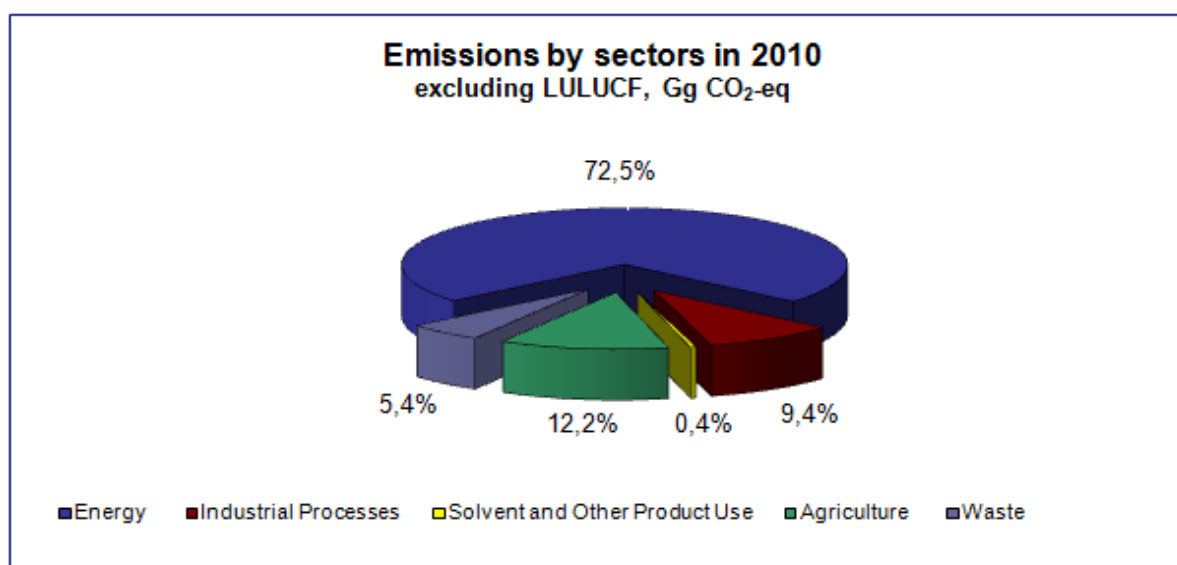
SF<sub>6</sub> emissions primarily depend on the uses in electricity transmission, as it is mainly used in electrical equipments, first of all in switchgears for insulation and arc quenching. So, the growth of the electricity consumption results in an increasing application of SF<sub>6</sub>, however it the tendencies vary according to the manufacturing/application needs.



**Figure 2.9. F-gases trend (1985-2010)**  
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 72.5% to the total GHG emission in 2010. Agriculture was the second largest sector with 12.2% while emissions from industrial processes (with solvent and other product use) accounted for 9.8% and the waste sector contributed 5.4%. Compared to the base year, emissions were significantly reduced in the energy (-37.7%), agriculture (-53.9%), and industrial processes (-56.4%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+19.9%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.



**Figure 2.10.** Shares of sectors in 2010

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. Between 2005 and 2008 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. And then the economic crisis came...

The energy sector was responsible for 72.5% of total GHG emissions in 2010. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 93.9% to sectoral emission. Considering fuel use in combustion processes, gases had the highest proportion (52.0%), liquids and solids represented 26.1% and 11.6%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 9.4%. The most important subsector was energy industries with a proportion of 34.0% within the energy sector, followed by other sectors (29.1%) and transport (24.2%). Fugitive emissions from fuels played only a small role with 4.8% out of which 70% originate from Natural Gas Production/Processing, Transmission and Distribution. While the fugitive emissions connected to Natural Gas operations show an increasing tendency (55% increase compared to the base year in subsector 1.B.2.b – Natural Gas mainly due to the spread of distribution network), the emission in subsector 1.B.1 – Fugitive emissions from solid fuels are 99% smaller than the base year caused by the huge recession of coal mining in Hungary. The aggregate change of sector 1B – Fugitive emissions is 18% decrease 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. In addition, ongoing changes in 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 increased by 1.1% or 0.5 million tonnes between 2009 and 2010. The growing energy demand of industry of 9% was the main driver of this increase. Besides, fuel consumption of public services, commerce, and domestic users was also higher than in 2009. Electricity production, where the GHG irrelevant nuclear production has a significant high share of more than 40%, also increased by about 4%. In contrast, after an increase of 88% between 1994 and 2008, transport emissions decreased in the second consecutive year, this time by 6.4%. This falling tendency is probably mainly due to the significantly higher fuel prices supported somewhat by the slightly growing biofuel use as well.

In 2010, agriculture was the second largest source of greenhouse gas emissions in Hungary. Emissions from agriculture include CH<sub>4</sub> and N<sub>2</sub>O gases: almost 85 percent of total N<sub>2</sub>O emissions were generated in agriculture in 2010. Emissions from agriculture decreased by 53.9% over the period of 1985-2010. The bulk of this decrease occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. The contribution of agriculture to total emissions decreased over the period 1985-2008 from 15.6% to its present share of 12.2%. Between 1996 and 2008, agricultural emissions stagnated around 9Mt with fluctuations up to 5%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers increased by 67.5% until 2007 which caused growing nitrous-oxide emissions from agricultural soils. In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels.

Agricultural emissions decreased both in 2009 and 2010. A major reduction in emissions occurred in 2009, when emissions decreased by 6 per cent due to the lower N<sub>2</sub>O emissions from agricultural soils. The main reason for this is the lower fertilizer consumption. The continued decline in animal husbandry also contributed to the emission reduction. In 2009 the swine population reduced by 11 per cent, in 2010 the cattle population fell by 5 per cent, resulting lower CH<sub>4</sub> and N<sub>2</sub>O emissions levels from animal husbandry. Although the fertilizer consumption was slightly higher in 2010 compared to 2009, there was a decline in the total agricultural emissions again, resulting in the lowest emissions levels in the whole time-series.

The **industrial processes** sector was the third largest sector, contributing 9.4% to total GHG emissions in 2010. (Solvent and other product use added further 0.4% to total emissions.) The most important greenhouse gas was CO<sub>2</sub>, contributing 81.2% to total sectoral GHG emissions, followed by F-gases with 18.0%. Within this sector, 35.2% of the emissions came from iron and steel industry, 22.1% from mineral products, followed by 18.0% from consumption of halocarbons and SF<sub>6</sub> and 16.6% from non-energy use of fuels. Process related industrial emissions decreased by 56.4% between base year and 2010, and by 18% between 2005 and 2010.

Although emissions of F-gases represent only 1.7% 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.

It has been the first year since 2005 when emissions increased again as GHG emissions from industrial processes sector were 7.4% (400 Gg) higher in 2010 than in 2009. There is still a decrease of 12.5% (202 Gg) of the emissions in category Mineral industry. Building industry is still struggling the recession (or stagnation) effecting of course building material producers, such as cement, glass, brick and tiles producers. Emissions from production of cement decreased by 24%, from glass production by 6%, and from brick and tiles production by 4%. However emissions have increased by 6.7% from consumption of halocarbons and



SF<sub>6</sub>, 9.1% in chemical industry, 18.2% in metal production and 20.4% by non-energy use of fuels compared to the previous year.

The **waste** sector represented 5.4% of total national GHG emissions in 2010. In contrast with other sectors, the emissions of waste sector showed significant increase from the base year (+19.9%). However, the growth of emissions stopped in recent years, moreover a reduction of 6.8% could be observed between 2005 and 2010. In all the years, the largest category was solid waste disposal on land, representing 79.9% in 2010, followed by wastewater handling (17.7%) and waste incineration (2.4%). Although degradation process takes many years after disposal, the amount of disposed waste had decreased significantly, by almost 30%, since 2005 which led to lower methane emissions. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

In the **Land Use Land-Use Change and Forestry** sector, using the currently available data, carbon uptake of the forests living biomass, non-CO<sub>2</sub> 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. The complex dynamics of the land use and land-use changes leads to highly fluctuating estimates of sectoral removals. Our estimates indicate an average annual 2.9 million tonnes removal, CO<sub>2</sub>-eq. net removals range from 0.07 million tonnes in 1985 to 5.8 million tonnes CO<sub>2</sub> in 1995. In 2010 the LULUCF sector accounted for 3.4 million tonnes carbon-dioxide removals. The removals of forests amounted to 3.1 million tonnes, while the living biomass of orchards and vineyards were a net source of carbon, because of the continuous decrease of vineyard areas in Hungary. The emission of the living biomass of vineyards and orchards accounted for 0.34 million tonnes CO<sub>2</sub> in 2010.

Our mineral soils in Cropland remove a small amount of carbon (0.92 Mt in 2010), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favourable processes that increase the soil carbon content.

As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.2 million tonnes CO<sub>2</sub>-eq. mainly due to afforestation and reforestation in 2010. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 1.7 million tonnes CO<sub>2</sub>-eq.

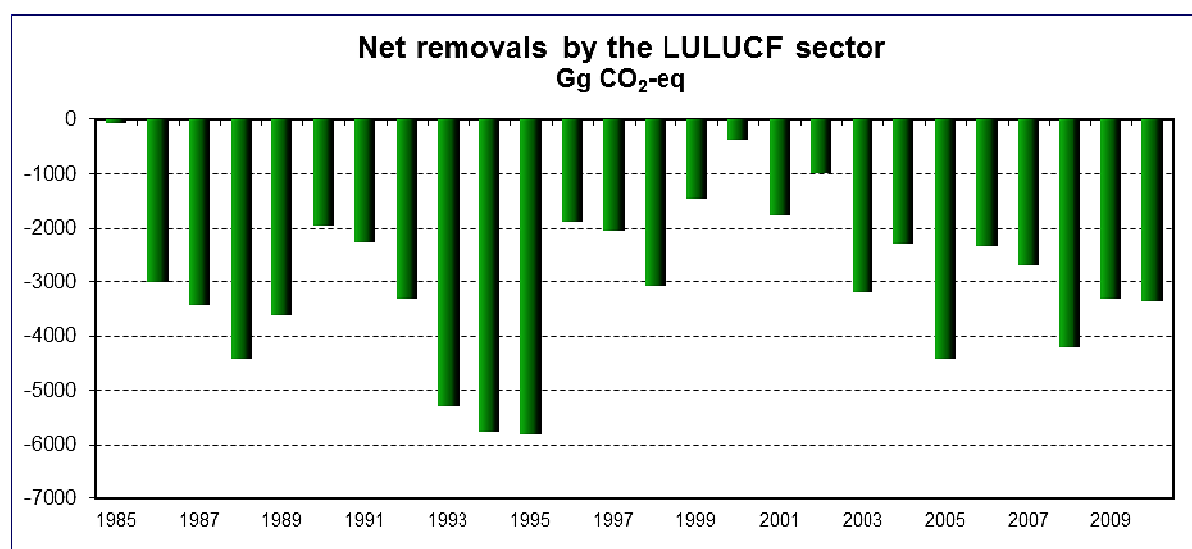


Figure 2.11. Sinks of LULUCF

## 2.4 Trends of indirect gases and SO<sub>2</sub>

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 2.3.** Trends in emissions of indirect greenhouse gases and SO<sub>2</sub>. The database are not complete for the beginning of the period.

Indirect gases	1985	1990	2000	2003	2005	2006	2007	2008	2009	2010
NOX, Gg	262.5	238.0	185.1	210.8	203.2	202.5	185.5	169.1	154.5	152.5
CO, Gg	931.1	997.0	558.8	566.3	554.9	561.0	542.1	538.4	527.0	533.5
NMVOC, Gg	232.0	205.0	159.1	167.9	170.0	178.0	156.9	157.2	121.8	109.9
SO <sub>2</sub> , Gg	1403.6	1010.0	488.9	347.8	147.8	123.1	98.6	105.6	89.4	36.9

The substantial reduction in sulphur dioxide emissions (-95%) is attributable to the decreased use of fossil fuels in general and the decreasing share of coal with higher sulphur content. After 2000, further reductions were observed due to the introduction of SO<sub>2</sub> precipitators in coal-fired power stations. Reduced carbon monoxide emissions are obviously a consequence of decreased fuel uses. The decrease in NO<sub>x</sub> emissions is relatively moderate due to the increasing significance of transport.

### 3 ENERGY (CRF sector 1)

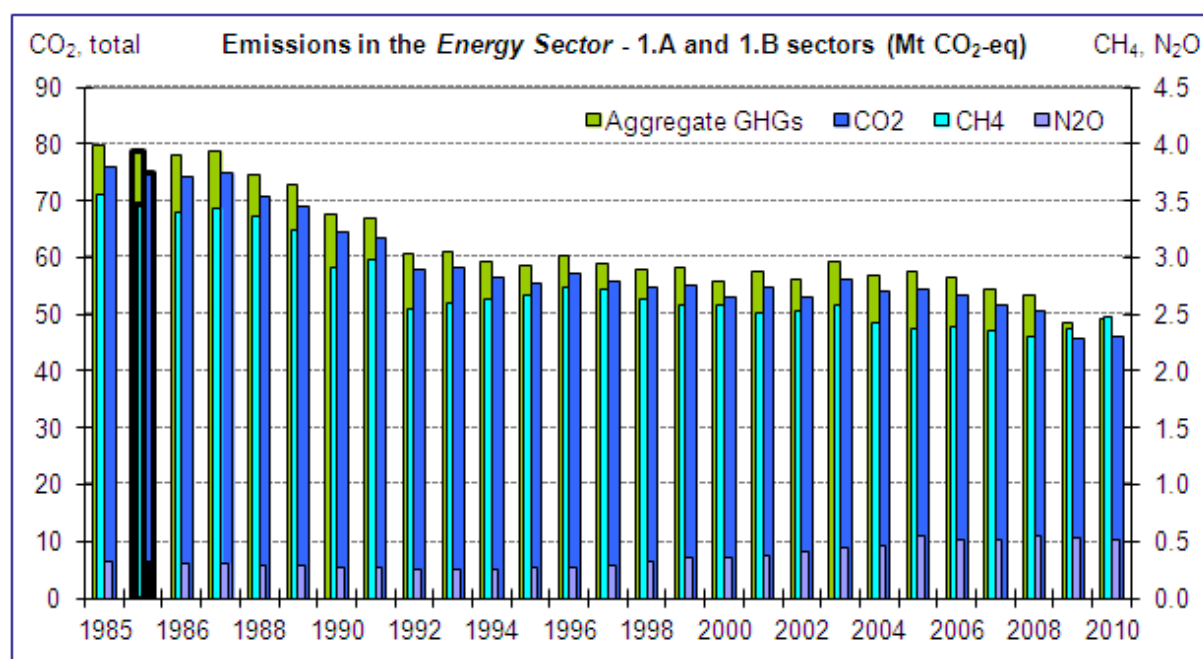
#### 3.1 Overview of sector

Emitted gases: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Methods: T1, T2, T3

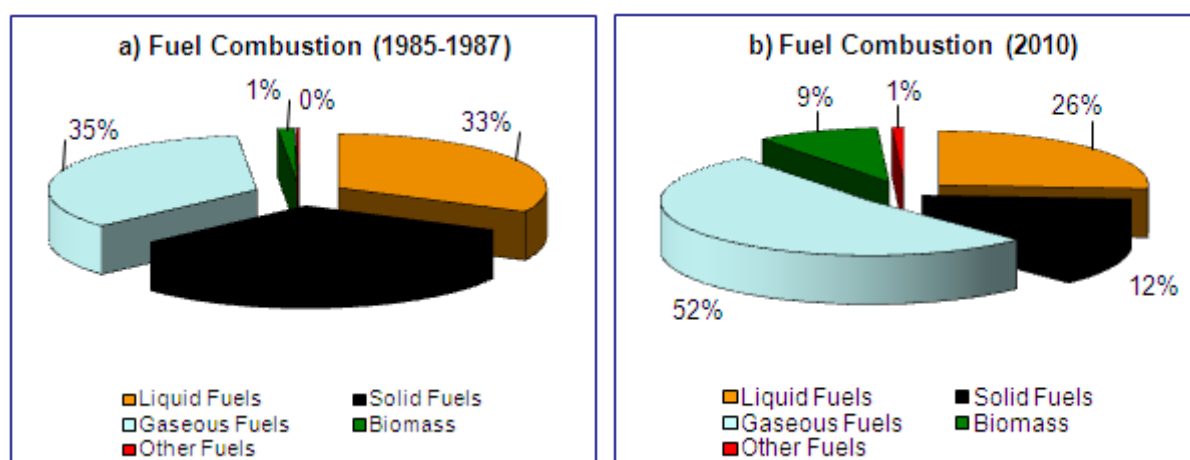
Emission factors: D, CS, OTH, PS

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.



**Figure 3.1.** CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Energy Sector (1985-2010)

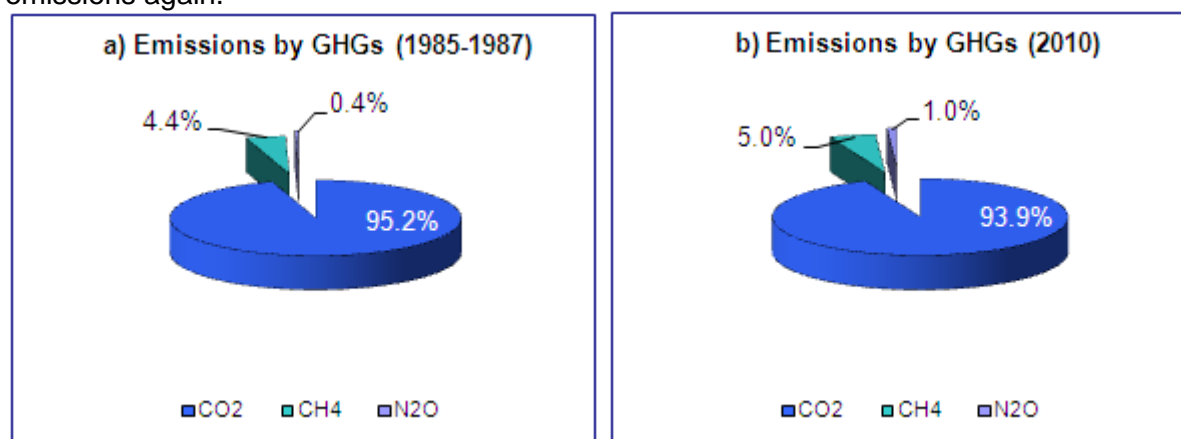
The principal driver of emissions in this sector is the fuel consumption. *Figure 3.2* represents the proportion of combusted fuel types in the base year and 2010.



**Figure 3.2.** Fuel combustion in the base year (a) and 2010 (b)

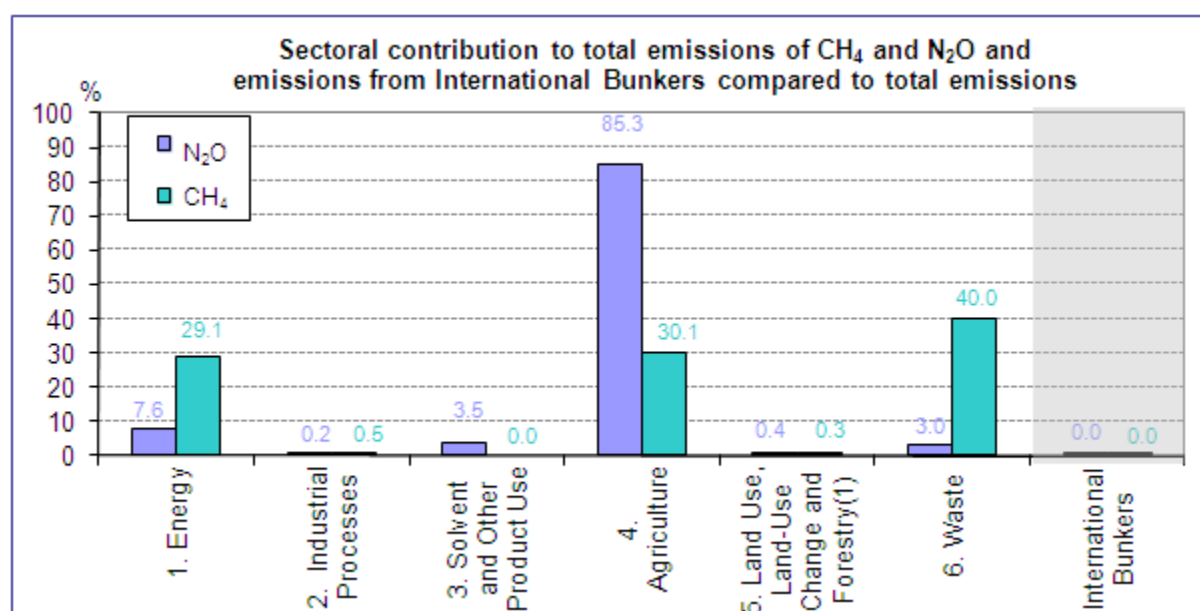
Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 93.9% to sectoral emission, followed by CH<sub>4</sub> with 5.0% and by N<sub>2</sub>O with 1.0%.

Among fuels, gases have the highest proportion (52%), liquids and solid have less (26% and 12%) and other fuels (waste) have the lowest representing 1% of the total fuel consumption. 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 of the base years, namely solid fuel has been replaced by natural gas, led to decreased total emission. In the last 3-4 years, Hungary experienced another emission reduction of about 9% in the energy sector basically due to mild winters and higher energy prices. In 2009 also the global economic crisis affected the emissions especially in the energy and manufacturing industries sectors. Then in 2010, the growth in industrial production led to a somewhat increased emissions again.



**Figure 3.3.** Distribution of emission of GHGs in the Energy Sector in the base year (a) and 2010 (b)

As regards methane emission, this sector represents 3.8% (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 29.1%, which represents the third highest emission compared to other sectors (Figure 3.4.).



**Figure 3.4..** Sectoral contribution to total emission of CH<sub>4</sub> and N<sub>2</sub>O in 2010

As regards nitrous oxide emission, this sector represents 0.8% (with LULUCF) of the total greenhouse gas emission. Among nitrous oxide emitters, its proportion is 7.6%, which represents the second highest emission compared to other sectors far behind agriculture

Emissions of the sector strongly depend on 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 proportion 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 34%, followed by *Other Sectors* (1.AA.4) and *Transport* (1.AA.3) representing 29 and 24% of the total emissions in this sector, respectively. Similarly to previous year the least contribution to the emission from fuel combustion has *Manufacturing Industries and Construction Sector* (1.AA.2) with 8% which share even decreased further due to the reallocation of emissions from most of the coke used in the iron and steel industry to the industrial processes sector. *Fugitive Emissions from Fuels* (1.B) play only a small role in emissions of the sector with 5%.



**Figure 3.5.** Proportions of energy consumption and emissions in the Energy Sector in the base year and 2010

Calculation of greenhouse gas emissions from combustion is based on the amount of fuel used. For this purpose, the energy balance of Hungary (summary table: see *Annex 2*), the fuel balance for each fuel type and the fuel consumption for each subsector prepared by the Energy Centre – Energy Efficiency, Environment and Energy Information Agency Non-Profit Company were used dominantly. Besides, the IEA/Eurostat statistics were taken into account. The Hungarian energy statistics has a chapter about the energy carries balances by branches. Nowadays, division into branches follows the structure of NACE Rev.2 (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, for example in case of manufacturing metal products. For this reason IPCC 1.AA.2.A and 1.AA.2.B were included together under 1.AA.2.A for a long time. However, following the recommendation of the ERT, we started to report emissions from these categories separately. 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 to fill in the CRF tables according to the guidelines.

In the Energy Statistics Yearbooks, the quantities of fuels are expressed in calorific values (see *Annex 2, Table A2-6*). 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.

Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary, Energy Statistics, the Hungarian Oil and Gas Company Plc. (MOL) and from the Hungarian Energy Office. LPG and petroleum coke was taken into account as liquid fuels which had 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

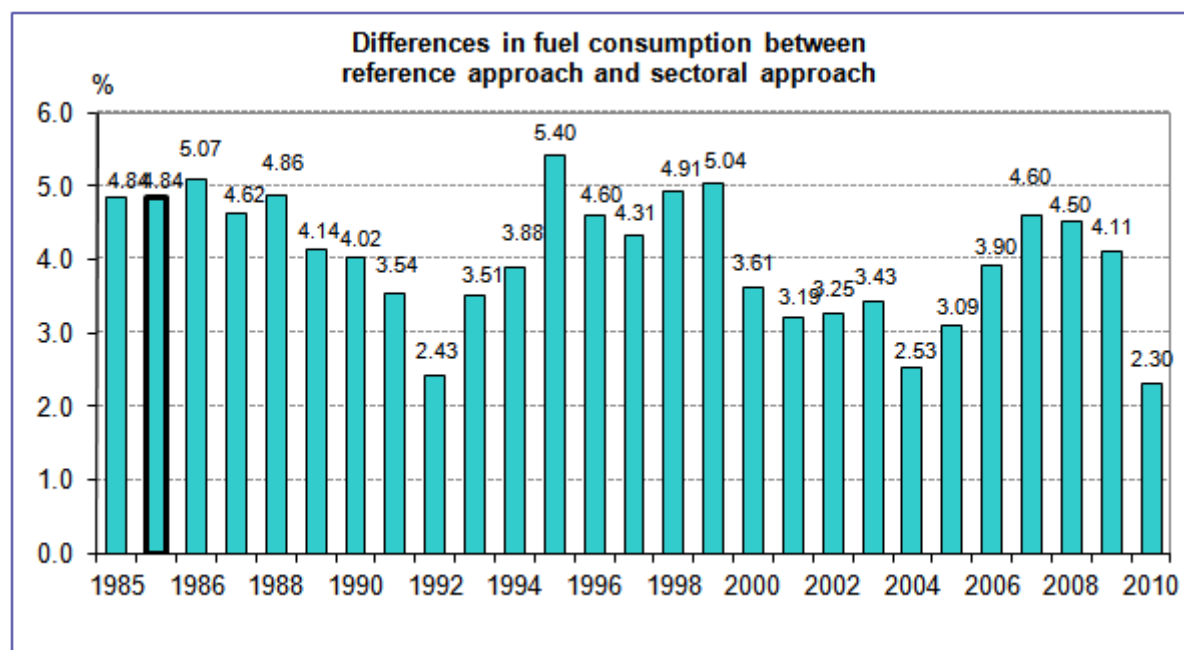
The quantity of CO<sub>2</sub> from energy consumption was determined on national level (*reference approach*) and on sectoral level (*sectoral approach*) as well.

The *reference approach* (RA) is based on national energy balance: production, import, export, stock changes, and international bunkers. It is necessary to use calorific values to harmonize information across all fuels. In our case, the apparent consumption of the energy balance components mentioned is already given in calorific value in the national energy statistics. Sectoral approach allocates the emissions by source category and includes only the combusted amount of fuels.

The *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 2010 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<sub>2</sub> 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<sub>2</sub> emissions from energy use of fossil fuels.

Emissions from feedstocks and non-energy use of fuels are taken into account in the Industrial Processes sector (2B and 2G) in case of *sectoral approach* (SA), therefore the energy and carbon content of these fuels are removed from the RA (the fraction of carbon stored is 1 for all these fuels in the 1D sector), too. Similarly, for the first time in 2012, emissions from coke used for transformation in the iron and steel industry were allocated to the relevant source category of the industrial processes sector, thus removed from the reference approach.

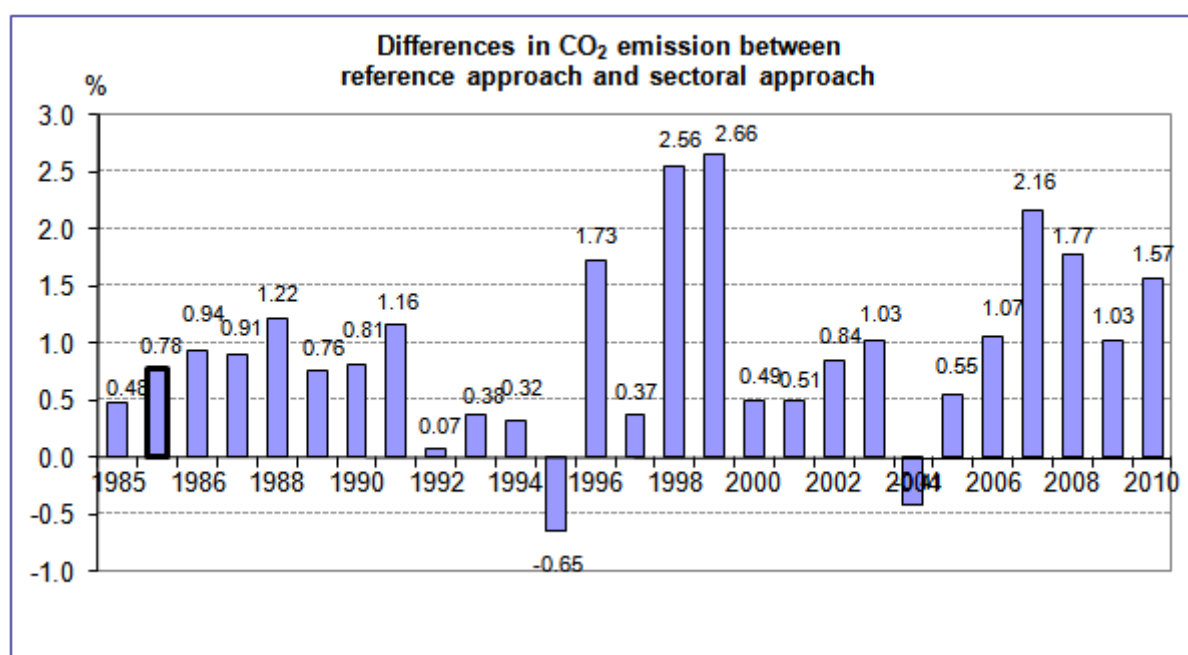


**Figure 3.6.. Comparison of sectoral and reference approach – fuel consumption**

In the CRF reporting software, the RA is directly compared with the sectoral fuel combustion total. This direct comparison of the energy outputs from the RA and the SA used in the Common Reporting Format (CRF) shows that the total fuel consumptions of the RA are consistently larger than the SA totals (*Figure 3.6.*). The remaining differences – after extracting the feedstock and non-energy use of fuels – are the fugitive emissions and the transformation losses which are occurring during coking, briquetting or oil refining. However, further analysis will be needed to explain the relatively large values in the above time series.



In 2010, comparing the two approaches the difference was 2.3% in energy consumption (*Figure 3.6.*) and 1.6% as regards CO<sub>2</sub> emission (*Figure 3.7.*). The range of differences are between 2.3% (2010) and 5.4% (1995) with a 4.0% mean value as regards the fuel consumptions, and -0.6% (1995) and 2.7% (1999) with a 0.9% mean value as regards the CO<sub>2</sub> emissions. Generally, as the time-series in case of SA might not fully be consistent as regards coke oven/blast furnace gas, and also the fugitive emissions in the RA were taken into account differently, the time-series of differences will be changed in future submissions and they may be more uniform.



**Figure 3.7.** Comparison of sectoral and reference approach – CO<sub>2</sub> 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<sub>2</sub> 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.

**Table 3.1.** Air travelling and transport performance in Hungary since 2000 in selected years

Air transport	2000	2005	2006	2007	2008	2009	2010
Passengers carried (thousands)	2,476	3,785	4,551	4,896	4,340	4,573	4,512
Transported quantity of goods (kt)	22	16	16	17	14	16	16
Quantity of kerosene (TJ)	8,957	9,368	9,210	10,145	11,303	10,584	9,618

(Source: HCSO, 2010; Energy Centre, 2011)

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 were 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

Since the 2010 submissions, feedstocks and non-energy use of liquid fuels have been removed from the sectoral approach for the entire time-series, the CO<sub>2</sub> emission originated from non-combustion can be found in the *Industrial Processes Sector*. From this year on, also most of coke consumption is accounted for under 2.C.1. 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.

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

Fuel type	Allocated under the sector...	IPCC code
Natural gas	Industrial processes – Ammonia and carbon black production	2.
Naphtha	Industrial processes – Feedstock and non-energy use of fuels	2.G
Bitumen	Industrial processes – Asphalt roofing, Road paving with asphalt	2.A.5-6
Gas/Diesel Oil	Industrial processes – Feedstock and non-energy use of fuels	2.G
LPG	Industrial processes – Feedstock and non-energy use of fuels	2.G
Other oils	Industrial processes – Feedstock and non-energy use of fuels	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
Coke	Industrial processes – Metal Production – Iron and Steel	2.C.1

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.

Coal oils and tars from coking coal is included with default factor for carbon stored in the 1.AD sector in this submission for 2008-2010.

Carbon content of all fuels which are allocated under the Industrial Processes sector is taken as stored carbon in the 1.AD sector (and in the *reference approach*), however the default factor of carbon stored (*Table 3.3*) is used in the appropriate industrial processes sector for the calculation of CO<sub>2</sub> emissions.

**Table 3.3.** Fraction of carbon stored used for the calculation of emissions from feedstock and non-energy use of fuels in the Industrial Processes sector (2G).

Fuel type	Fraction of carbon stored (default IPCC)
Naphtha	0.8
Gas/Diesel Oil	0.5
LPG	0.8
Other oils	lubricants: 0.5, other: 0.8

### 3.2.4 CO<sub>2</sub> capture from flue gases and subsequent CO<sub>2</sub> storage

There are no activities in these categories.

### 3.2.5 Country-specific issues: on the use of plant level EU-ETS data

It is important to note first that no emission data are taken directly from the ETS database and put into the CRF as they are. Instead, facility level activity data (fuel use) and carbon emission factors are used from the ETS database to calculate weighted averages of the emission factors for different fuel types. These derived country specific EFs are then applied with the fuel use from the national energy statistics. The time series of these country specific emission factors and their comparison with the default values are summarized in *Table 3.4*. Fuel uses in energy statistics and ETS are compared also to see whether the fuel use in a given category is fully covered by ETS plants or not. Fuel consumption data are compared both in natural units and in energy units to reveal any possible differences in net calorific values. Should such difference occur, emission factors need to be amended to achieve consistency in energy balance and verified emissions since national energy data serve always as activity data. It is also checked whether the oxidation factor used by the facilities is included in their EFs. Measured oxidation factors, especially in case of coal firing plants, are always taken into account.

**Table 3.4.** Country specific emission factors derived from the EU ETS database

	Default	2007	2008	2009	2010
Gasoil	20.2	22.9	20.2	21.6	22.4
Heavy fuel oil	21.1	21.5	22.4	21.0	21.1
Other oil	20.0	22.0	22.0	22.0	21.8
Other bituminous coal	25.8	26.1	26.1	25.2	25.3
Brown coal	26.2	27.4	27.2	27.1	26.6
Lignite	27.6	30.7	30.3	30.6	30.2
Coke oven gas	13.0	11.9	11.9	12.4	13.0

	Default	2007	2008	2009	2010
Coke oven coke	29.5	29.5	29.2	29.4	29.4

Other country-specific issues are included under the source category descriptions and methodological chapter of each category.

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

#### 3.2.6.1 Source category description

Emitted gases: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

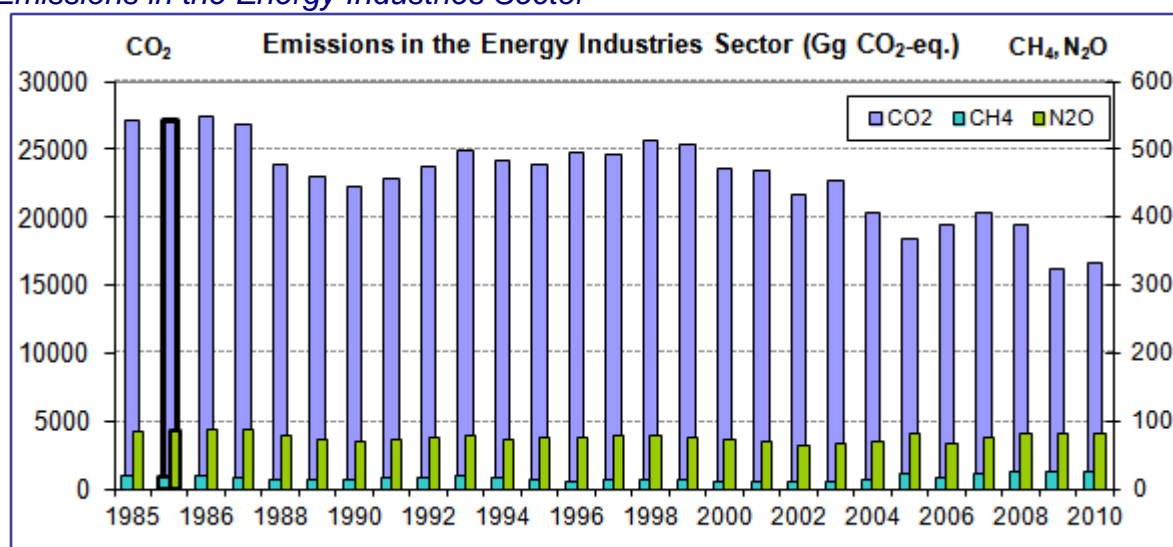
Methods: T1, T2, T3

Emission factors: D, CS, PS

Key source: Level and Trend: Public electricity and heat production, CO<sub>2</sub>; Petroleum refining, CO<sub>2</sub>

This subsector includes facilities generating electricity, district heating stations, oil refineries and coking and briquetting plants. On an overall level, here are the largest energy consumers. In 2010, 33% of the domestic energy consumption was used by energy industries.

#### Emissions in the Energy Industries Sector



**Figure 3.8.** Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Energy Industries (1985-2010)

#### 3.2.6.2 Methodological issues

##### Activity data

Energy consumption data were taken from the energy balance (1985-2010) of the Energy Statistics Yearbooks prepared by the Energy Centre. Besides, waste statistics and ETS data were taken into account.

The Hungarian coal terminology slightly differs from that of the IPCC. The partitioning is created according to the age of coal; *Table 3.5* shows the classification according to the

Hungarian and IPCC categories. Practically this means that imported “brown coal” in the Hungarian terminology would classify as sub-bituminous coal whereas domestically produced brown coal falls under the IPCC category of lignite. The 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, 1985-2010) or annual coal questionnaires (1990-2010) prepared for IEA by Energy Centre, for the distribution of the use of each coal type.

**Table 3.5.** Comparison of Hungarian and IPCC coal terminology

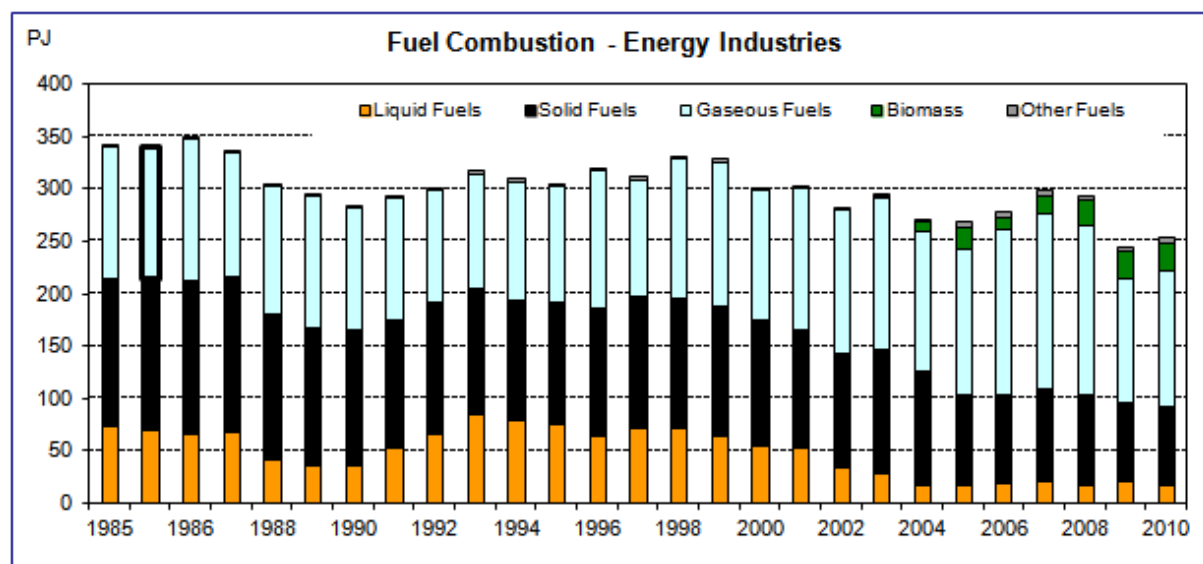
Hungarian Terminology	Net Calorific Values	IPCC Category (Gross calorific value)
Hard Coal	17-33 MJ/kg	Other Bituminous Coal (>23.865 MJ/kg)
Hard Coal	17-33 MJ/kg	Sub-Bituminous Coal (17.435 MJ/kg -23.865 MJ/kg)
Brown Coal	10-17 MJ/kg	Lignite (<17.435 MJ/kg)
Lignite (young brown coal)	3.5-10 MJ/kg	Lignite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

(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.

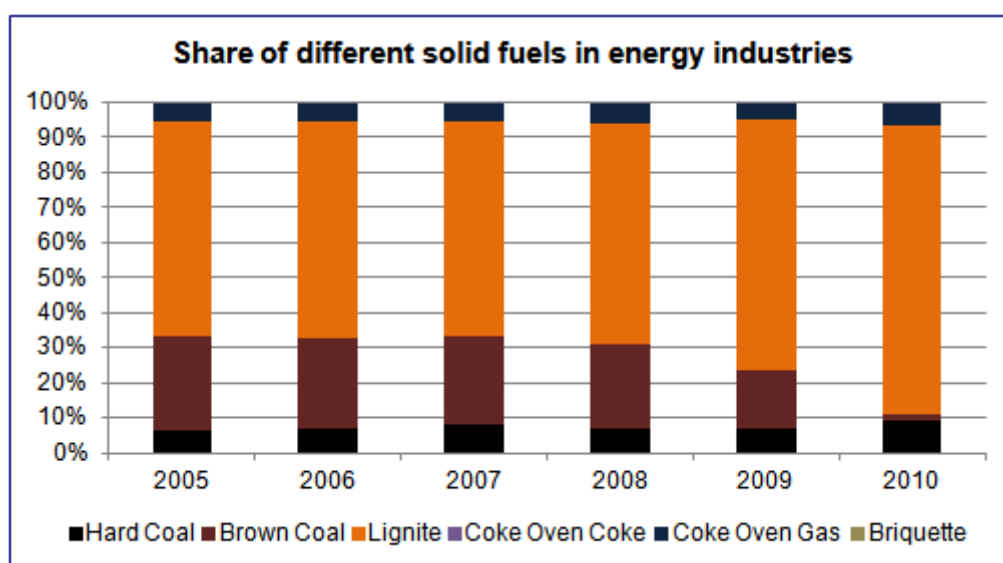
As it can be seen in Figure 3.9, total fuel consumption in the energy industries sector shows strong fluctuations. Of course, we had a significant decrease around the political and economic regime change in 1990, then some increase till 1998, then a slight decrease till 2005 and a more pronounced drop after 2008 due to the global financial crisis. 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. The biomass use due to burning and the so-called co-burning in power plants has become more and more important and exceeded 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 which is also 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. In 2009, the electricity generation in Hungary was by 10.3% less than in 2008. The generation decrease of power plants of 50 MW and higher capacity was 11.6% while it was 2.8% in case of small power plants. The fuel-mix also changed in 2009: coal and natural gas consumption decreased, however liquid fuel use increased, but its contribution to total fuel consumption is very low. Use of nuclear, waste and renewable sources continued to increase. In 2010 domestic electricity production increased again by 4%.

The fuel consumption of oil refining has been quite uniform with a very moderate decreasing since 2005, but its behavior does not affect the whole tendency of the sector, because the contribution of its fuel consumption and GHG emissions is less than 10%.

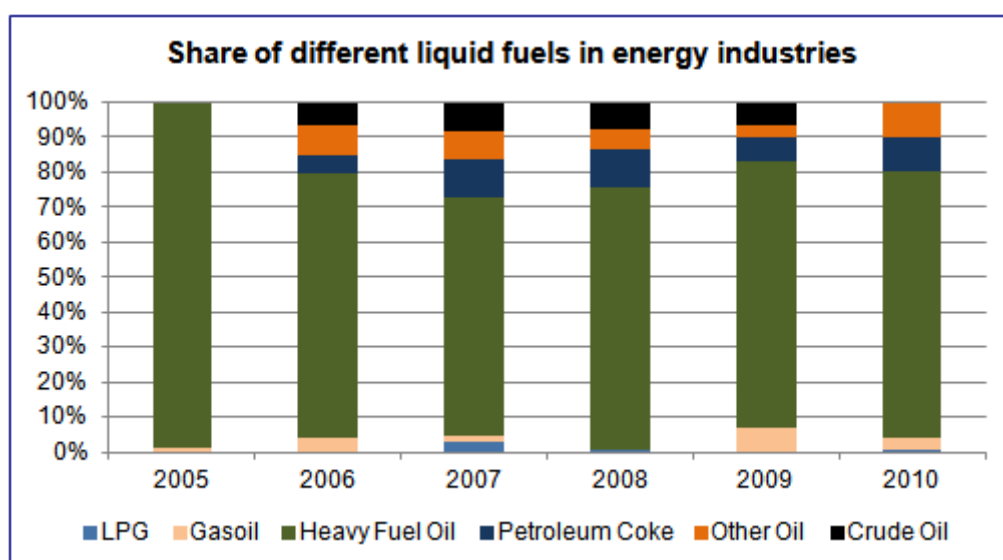


**Figure 3.9.** Fuel combustion in the Energy Industries Sector (1985-2010)

Going into more detail regarding fuel use, it can be seen that domestically produced lignite is the dominant fuel among solid fuels (Fig. 3.10). Liquid fuel use became almost negligible and shows a bit greater variability as regards fuel mix. Nevertheless, heavy fuel oil remained the most used fuel type (Fig. 3.11.)



**Figure 3.10.** Share of different solid fuels used by energy industries (2005-2010)



**Figure 3.11..** Share of different liquid fuels used by energy industries (2005-2010)

### 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 3.6*.

**Table 3.6.** CO<sub>2</sub> emission factors used in energy industry in the 2010 inventory year

Fuel type	Emission factor (CO <sub>2</sub> t/TJ)	Oxidation factor
Coking coal	94.6	0.98
<b>Other Bituminous Coal</b>	<b>92.8</b>	<b>0.96</b>
<b>Sub-Bituminous Coal</b>	<b>97.6</b>	<b>0.98</b>
<b>Lignite (brown coal + lignite)</b>	<b>110.9</b>	<b>0.97</b>
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Coke Oven Gas	47.7	0.995
Crude Oil	73.34	0.99
NGL	63.07	0.99
Gasoline	69.3	0.99
Jet Kerosene	71.5	0.99
<b>Gas/Diesel Oil</b>	<b>82.2</b>	<b>0.99</b>
Residual Fuel Oil	77.4	0.99
LPG	63.07	0.99
Bitumen	80.67	0.99
Petroleum Coke	98.08	0.99
<b>Other Oil</b>	<b>80.1</b>	<b>1.00</b>
Natural Gas	56.1	0.995
Biomass (Solid and Gaseous)	109.63	0.99

Fuel type	Emission factor (CO <sub>2</sub> t/TJ)	Oxidation factor
<b>Waste</b>	<b>61.6*</b>	<b>1.00</b>

(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<sub>2</sub> emission factors can be found in Annex 2. It should be noted that only those measured factors were applied where the EU ETS covers all or most of the installation of the sector. Default emission factors for methane and nitrous oxide have been used in the case of liquid fuels since last year. Country specific N<sub>2</sub>O emission factor for solid fuels was changed to default value from 2006 IPCC Guidelines. The following values were used for the calculations:

**Table 3.7. Special emission factors for methane and nitrous oxide in energy industry**

Special Emission Factors (kg/TJ)	Power station		District heating station		Petroleum refining	
	CH <sub>4</sub>	N <sub>2</sub> O	CH <sub>4</sub>	N <sub>2</sub> O	CH <sub>4</sub>	N <sub>2</sub> O
<b>Fuel type</b>						
<b>Coal</b>	1.25 <sup>3)</sup>	1.50 <sup>2)</sup>	1.25 <sup>3)</sup>	1.50 <sup>2)</sup>	–	–
<b>Natural Gas</b>	1.00 <sup>1)</sup>	0.1 <sup>1)</sup>	1.00 <sup>1)</sup>	0.1 <sup>1)</sup>	1.00 <sup>2)</sup>	0.10 <sup>2)</sup>
<b>Residual Fuel oil</b>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>
<b>Gas/Diesel Oil</b>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>
<b>LPG</b>	–	–	–	–	3.00 <sup>1)</sup>	0.60 <sup>1)</sup>
<b>Firewood</b>	30.00 <sup>1)</sup>	4.00 <sup>1)</sup>	–	–	–	–

Source: 1) Revised 1996 Guidelines (IPCC, 1997)

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).

As recommended by the ERT and required by the guidelines, emissions from waste incineration for energy purposes are allocated 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 (1985-2010), the Hungarian Waste Management Information System (2004-2010) and the ETS data (2006-2010). 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:

**Table 3.8.** NCVs for different waste types in 2010

EWC codes/type of waste	GJ/t	Range	Source
02: Wastes from agriculture and food proc.	16.0	12.2-19.5	ETS data
03: Wastes from wood processing	14.0	13.2-14.7	ETS data
Rubber (tires)	26.0		ETS data
Plastic	27.5	22.8-32.1	ETS data
MSW	8.5		FKF 2007 data
Paper	17.0	15.7-18.6	Literature
Hazardous waste	20.0		Estimation
Wastes from waste management facilities	20.0		Estimation
Tire textiles	28.7	27.4-30.0	ETS data

As only CO<sub>2</sub> emissions resulting from incineration of carbon in waste of fossil origin should be included in the national CO<sub>2</sub> 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<sub>2</sub> assuming a production rate of 1 t CO<sub>2</sub>/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 2009, data of the detailed Waste Management Information System were used which made possible to apply Tier 2 method for calculating CO<sub>2</sub> 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 17.0% showing a growing trend in the last six years. CO<sub>2</sub> emissions were estimated then with the assumption of default 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<sub>2</sub> emissions were taken over.

For the first time, CH<sub>4</sub> 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<sub>2</sub>O 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<sub>2</sub>-eq to GHG emissions in this category recently.

### 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  $\pm 2\%$ . 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<sub>2</sub> is 5%. The uncertainty of the methane factor is



slightly higher (8%), while that of N<sub>2</sub>O may be really high (50%). According to the CORINAIR Handbook, it may be as high as 100%.

The time series are not fully consistent. Although coke oven gas has been added this year, emission from energy consumption in *manufacturing of solid fuels* is calculated *fully* only for the last five years (2006-2010). Until 2005, fuel use of coking and briquetting was part of the *Chemicals and Other Industry* categories in the Hungarian Energy Statistical Yearbooks. 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

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 the IEA. This verification already pointed out some problems (e.g. on coke oven/blast furnace gas use) which were corrected in this submission. More details are in *Chapter 10.2*. This work, i.e. a comprehensive consistency check between data in the IEA time series and the Hungarian Energy Statistical Yearbooks will be continued.

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 for some years to achieve consistency in energy balance and verified emissions. 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. For the main power plants the total fuel consumption's difference between the ETS and this dataset was around 1% in 2009.

#### 3.2.6.5 Source-specific recalculations

Emissions from coke oven gas consumption has been added to the category 1.AA.1.C Manufacture of Solid Fuels for the period 1985-2005 which led to an increase of emissions of 55 to 175 Gg in CO<sub>2</sub> eq. Besides, CO<sub>2</sub> emission from blast furnace gas has been removed for the year 2005. More details can be found in Chapter 10.

#### 3.2.6.6 Source-specific planned improvements

The inventory division has direct access to the emission reports from polluters under the governmental decree 21/2001 (it was indicated in the previous submission). We have began to analyze them, but the accessible dataset must be expanded with other background data (e.g. activity data, information about the calculations'/measurements' method) to create appropriate country/plant specific emission factors. The dataset includes installation from the energy industries and from manufacturing industries, too.

Further check on consistent accounting of coke oven/blast furnace gas is planned within the framework of a general consistency analysis of IEA data and national energy statistics.



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

#### 3.2.7.1 Source category description

Emitted gases: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Methods: T1, T2

Emission factors: D, CS, PS

Key source: Level and Trend: Iron and Steel, Food processing, beverages and tobacco, CO<sub>2</sub>; Other, CO<sub>2</sub>, Level. Chemicals

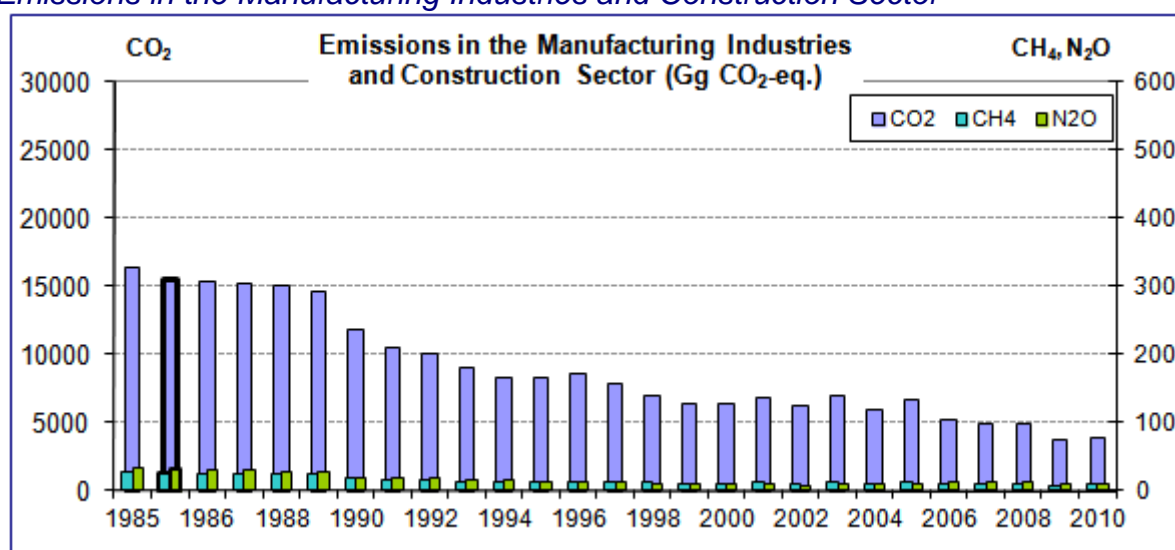
This subsector covers emissions from the combustion of fuels in the industrial sector. Owing to the traditions of the national statistics system, combustion emissions from energy conversion (coke production) was also calculated here between 1985 and 2005. Special attention was paid to avoid double accounting. In the *Other* 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:

- Manufacture of non-metallic minerals  
(separate subcategory under the *Other* subsector)
- 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

Manufacture of iron and steel (IPCC 1.AA.2.A) and non-ferrous metals (1.AA.2.B) are included together under 1.AA.2.A because of statistical reasons for most of the years but reported separately for 2010. From the most recent data it can be seen that emissions from non-ferrous metals is almost negligible compared to iron and steel (7%).

#### Emissions in the Manufacturing Industries and Construction Sector



**Figure 3.12.. Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Manufacturing Industries and Construction Sector (1985-2010)**

### 3.2.7.2 Methodological issues

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 3.2.6).

Feedstock and non-energy use of liquid fuels were removed from the *Chemicals* subsector for the entire time-series following the recommendation of the ERT. Now, the CO<sub>2</sub> 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<sub>2</sub> emissions were never calculated according to the methodology of the IPCC 1996 and 2000 guidance.

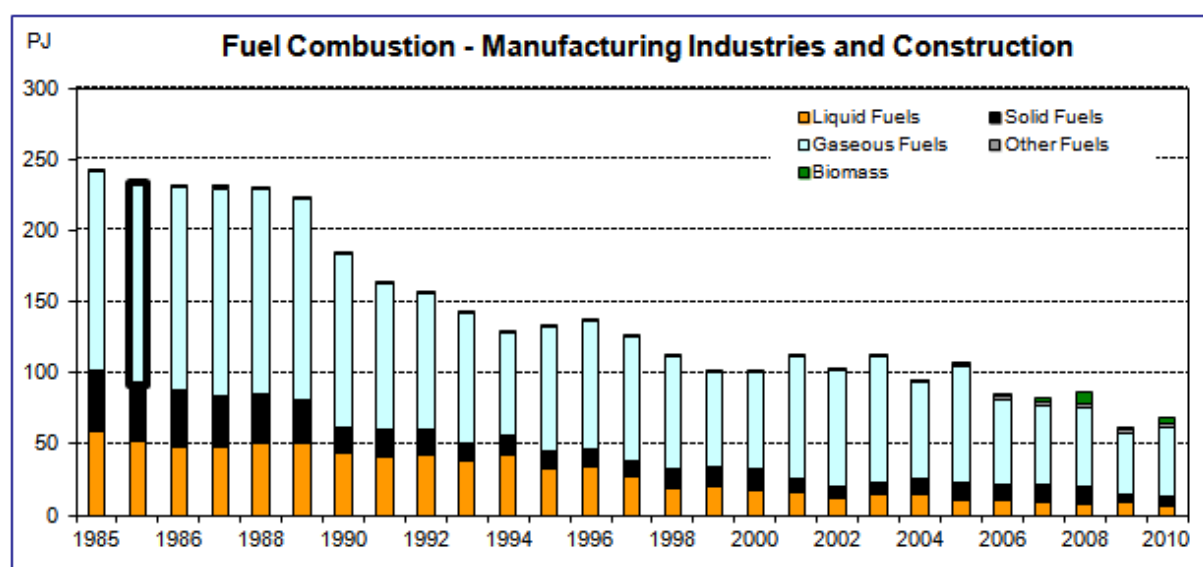
The other feedstock and non-energy products are reported under 2.G in two aggregated categories, because the exact place of conversion of feedstock within the chemical industry is not known – presumably it is confidential data because of limited number of manufacturers. The same aggregation was applied for non-energy use of fuels.

Part of the emissions from waste incineration for energy purposes was 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 chapter 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 CO<sub>2</sub>/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<sub>2</sub> emissions did not contribute to the national total. The insignificant CH<sub>4</sub> and N<sub>2</sub>O 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.

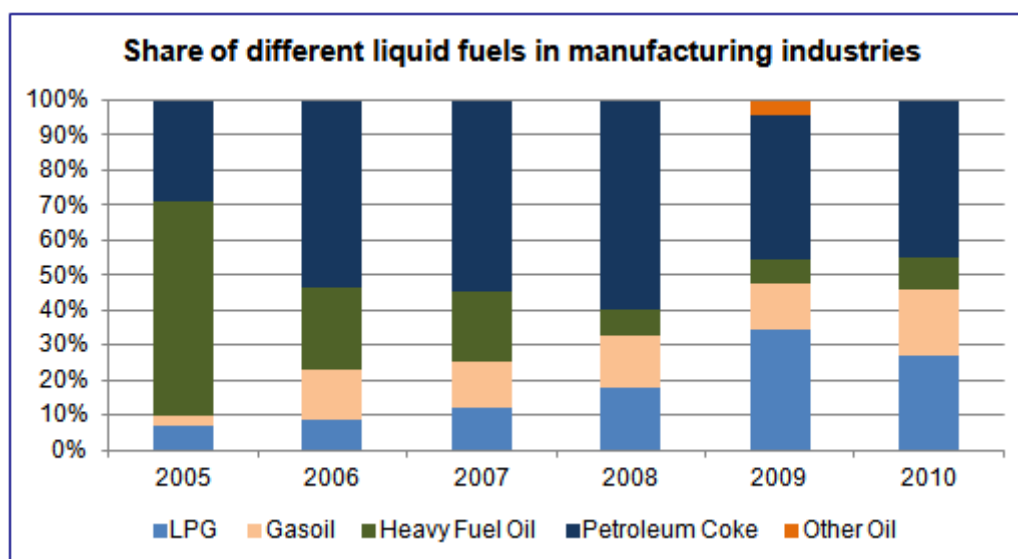
#### Activity data

Figure 3.13 illustrates the energy consumption of the sector. After 1990, following the economic changes, fuel use has been significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data presented in the *Industrial Processes Sector* (Chapter 4).



**Figure 3.13.** Fuel combustion in the Manufacturing Industries and Construction Sector (1985-2010)

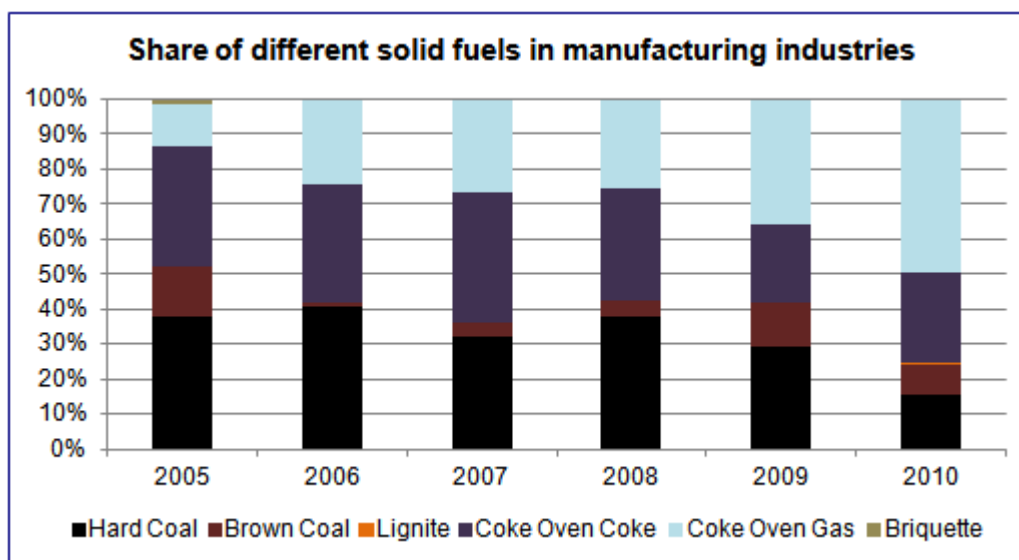
In 2005 the higher energy use of the industry is linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products, primarily glass, and chemical industry. Growing biomass use has become popular especially in the last three-four years, like in the *energy industries* sector. Combustion of oil products continues to lose its importance among fossil fuels. Methane and nitrous oxide emissions increased significantly due to higher biomass consumption in the last five years. In 2009 the global economic crisis continued to reduce the fuel consumption and also the emission of the industrial sector. The fuel mix also changed in 2009, the dominance of natural gas consumption declined whereas the use of LPG got more widespread. In 2010, the growing industrial production increased the energy demand.



**Figure 3.14.** Share of different liquid fuels used by manufacturing industries (2005-2010)

Overall, similarly to liquid fuels, the share of solid fuels has been quite low while in a sharp contrast with the beginning of the time series. The fuel mix has been changing also as demonstrated by Fig. 3.15. The growing relative share of coke over gas led to decreased solid fuel CO<sub>2</sub> IEF in the iron and steel category since coke oven gas has a very low CO<sub>2</sub> emission factor (see Table 3.6.). It is worth noting the relatively high IEF in food processing,

beverages and tobacco which is due to the fact that dominantly (recently exclusively) coke was used as solid fuel by this industry.



**Figure 3.15.** Share of different solid fuels used by manufacturing industries (2005-2010)

Feedstocks and non-energy use of liquid fuels were removed from the *Chemicals* subsector, the CO<sub>2</sub> emission originated from non-combustion processes can be found in the *Industrial Processes Sector* (mostly under 2.G).

CO<sub>2</sub> emission in the process of manufacturing bricks and ceramics is calculated using the verified emission reports (EU ETS) in the *Industrial Processes Sector*. In those cases when solid and liquid (petroleum coke) fuels and natural gas were reported together as fuel for the technological heat production, fuel consumption and emission from solid and/or liquid fuels were calculated under the *Industrial Processes Sector*. It was assumed that these fuels serve only as additives increasing the porosity of bricks.

### Emission factors

Mainly default CO<sub>2</sub> factors are used in this sector with one main exception. For coke oven coke combusted by the iron and steel industry where measured (by accredited laboratory) carbon content of fuels were available from the EU ETS, the resulting carbon dioxide emission factor was 107.7 t CO<sub>2</sub>/TJ in 2010. (It has to be noted, though, that most of the coke oven coke use was reallocated to the industrial processes sector.)

Following the general guidance of the ERT during the in-country review in 2010, Hungary switched to default emission factors for methane and nitrous oxide in the entire sector. In former inventories, emission factors were taken from the CORINAIR Guidebook, and from an international literature review prepared by a Hungarian expert (Tajthy, 1994). The following table contains the default values used for the current calculations. The formerly used EFs are in brackets:

**Table 3.9.** Emission factors for CH<sub>4</sub> and N<sub>2</sub>O in manufacturing industries and construction

Fuel type	CH <sub>4</sub> EF (kg/TJ)	Source of EF	N <sub>2</sub> O EF (kg/TJ)	Source of EF
<b>Solid fuels</b>	10.0 (100.0)	1996 Guidelines (Tajthy, 1994)	1.4 (3-5)	1996 Guidelines (Tajthy, 1994)
<b>Natural gas</b>	5.0	default IPCC, 1997	0.1 (3.0)	default (CORINAIR)
<b>Oil</b>	2.0 (2.0-2.2)	default IPCC (Tajthy, 1994)	0,6 (3-10)	default (Tajthy, 1994)

Fuel type	CH <sub>4</sub> EF (kg/TJ)	Source of EF	N <sub>2</sub> O EF (kg/TJ)	Source of EF
Wood	30.0 (40.0)	default IPCC (Tajthy, 1994)	4.0 (80.0)	default (Tajthy, 1994)

Values in brackets are the old factors used in previous submissions.

### 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  $\pm 2\%$  to 5% in consideration of the fact that uses are less easy traceable due to the high number of users.

The estimated specific uncertainty for CO<sub>2</sub> is 5%. The uncertainty of the methane factor is slightly higher (8%), while that of N<sub>2</sub>O 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 2006-2009 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.

Natural gas consumption reported in energy statistics as feedstock of the chemical industry was cross-checked with the *Industrial Processes* sector.

### 3.2.7.5 Source-specific recalculations

Following the recommendations of the ERT, three main changes occurred in this source category:

- Coke used as reducing agent has been removed from the energy sector and allocated to the industrial processes sector;
- Emissions from coke oven gas has been added, where necessary;
- We started the report emissions by non-ferrous metals separately from iron and steel.

More details in chapter 10.2.2 and 10.2.3.

### 3.2.7.6 Source-specific planned improvements

It was reported in previous NIRs that the public available statistical disaggregation of manufacturing industries were changed several times. Before 1998 the fuel consumption of each CRF industrial category based on expert estimates knowing changes in industrial production rates and other relevant background information on industrial data. It was planned for 2011-2012 in a framework of a contract with the Energy Centre to recalculate the real consumption of each category according to the database of the Energy Statistics. Meanwhile, the Hungarian Energy Office took over the role of the official energy statistics provider, therefore this project had to be postponed for the time being. Nevertheless, a comprehensive consistency check between the IEA time series with the national energy statistics is planned in the next inventory cycle.

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

#### 3.2.8.1 Source category description

Emitted gases: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Methods: T1, T2

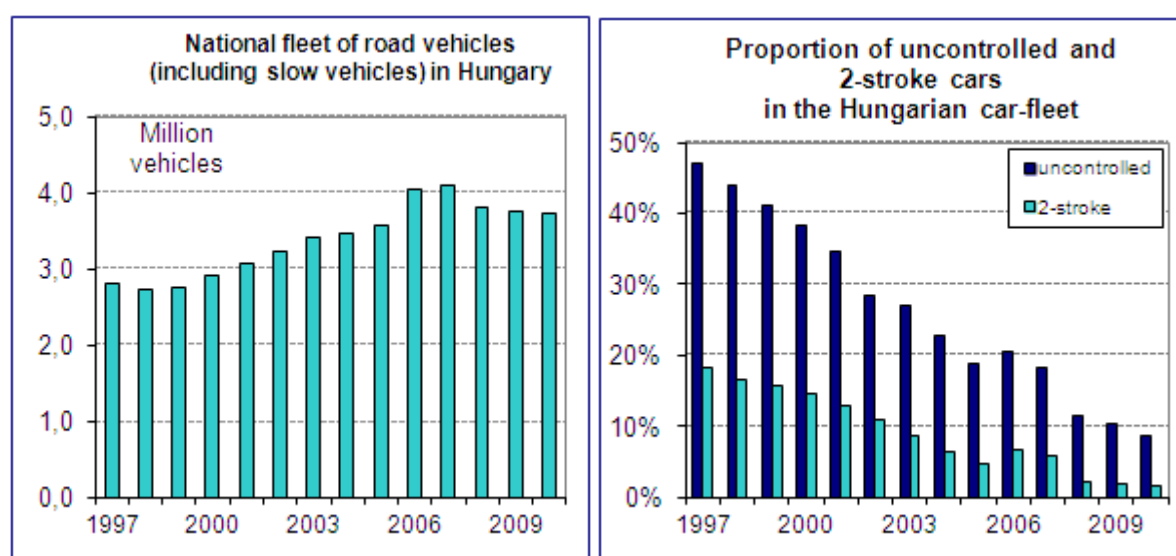
Emission factors: D, CS

Key source: Level and Trend: Road transportation, CO<sub>2</sub> and N<sub>2</sub>O;

Level: Railways, CO<sub>2</sub>

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, almost 90% of the vehicles are more advanced cars. *Figure 3.16* shows the changes in composition of the Hungarian car fleet from 1997.



**Figure 3.16.** Changes in stock and composition of road vehicles

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.

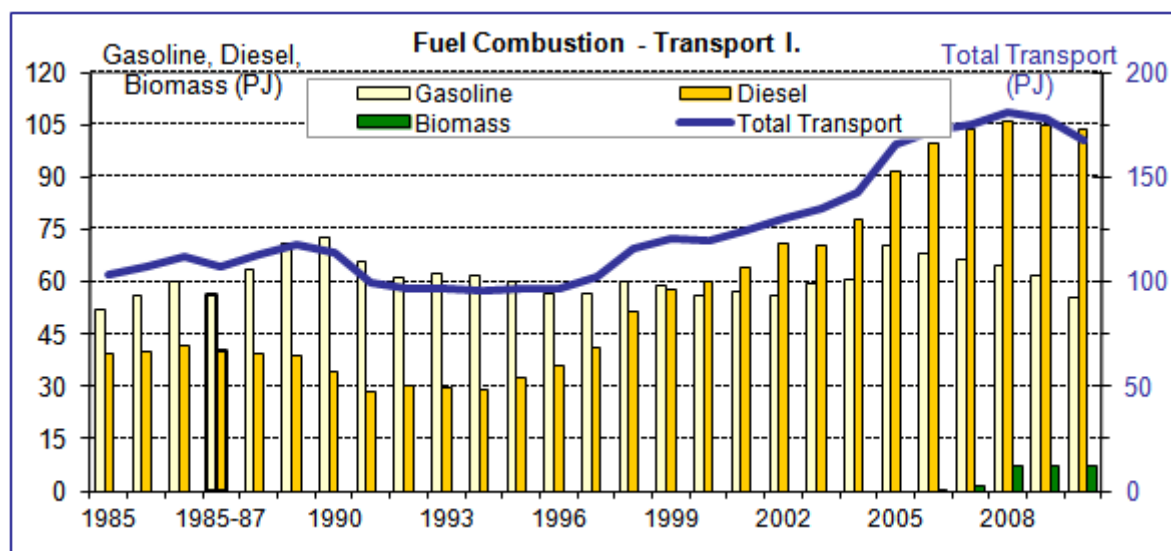
Emissions were calculated from the national fuel consumption data published in Energy Statistics Yearbook (1985-2010).

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.

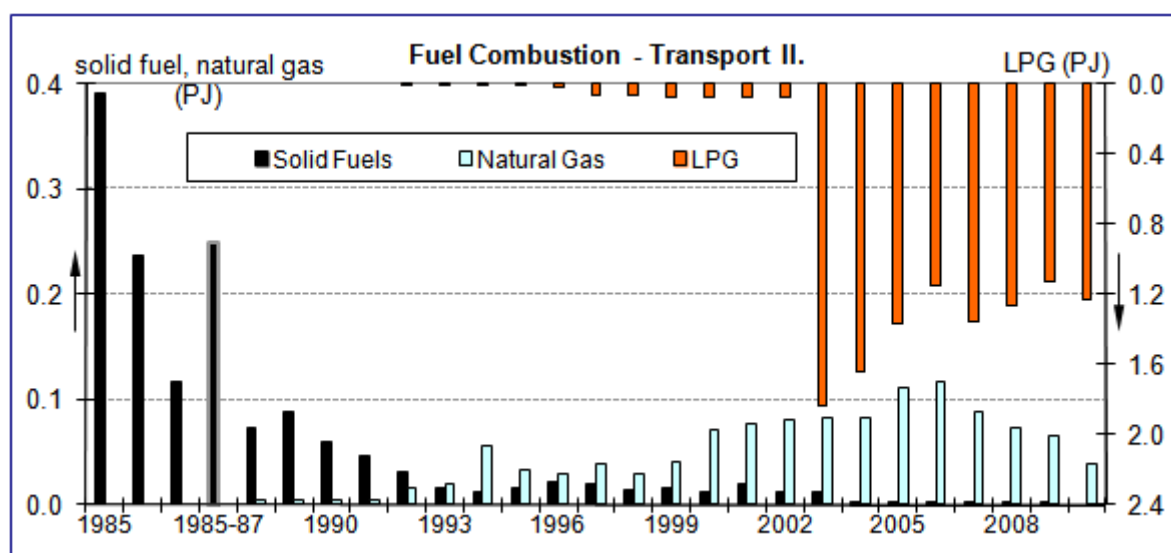
Emissions from combustion related to natural gas transport are included under sector 1.AA.2 (*Manufacturing Industries and Construction*) instead of *Other Transport*. Nevertheless, we have checked that five compressor stations reported under the EU-ETS in 2010. Their aggregated natural gas use was 1.9 PJ which led to a reported CO<sub>2</sub> emission of 106 Gg.

Figures below illustrate fuel consumption of the sector:





**Figure 3.17.** Gasoline, diesel and biomass consumption and total energy use in the Transport Sector (1985-2010)

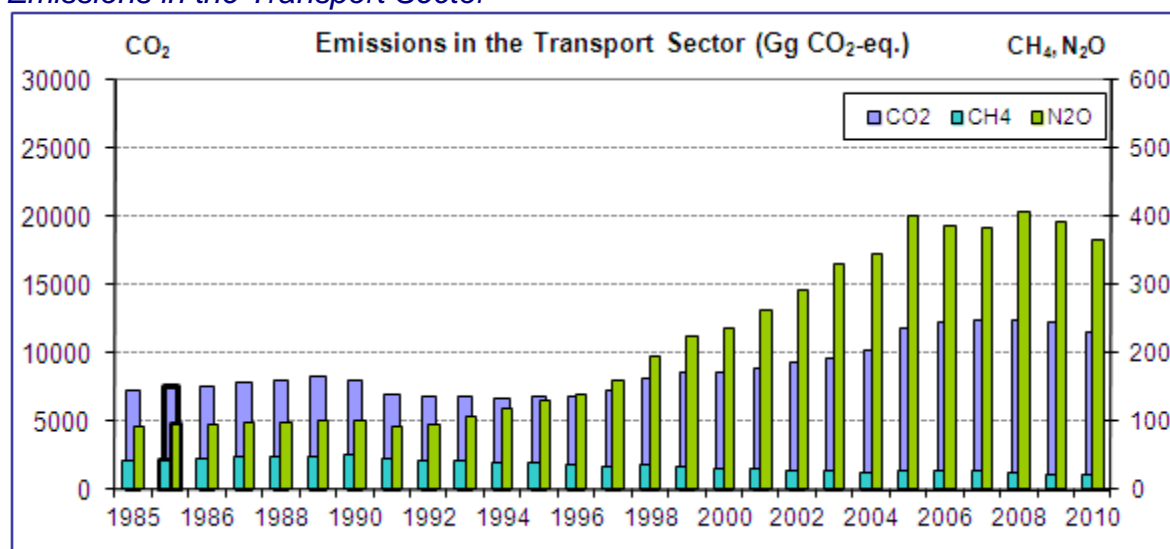


**Figure 3.18.** LPG, natural gas and solid fuel combustion in the Transport Sector (1985-2010)

Figure 3.17. shows clearly that in contrast to the other described sectors, transport consumption shows a rising overall tendency from the mid 90's until 2008. Starting in 2009 the trend of fuel consumption has changed due to the economic crisis. 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 Fig. 3.13. 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 3.2.9.1).

### Emissions in the Transport Sector



**Figure 3.19.** Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Transport Sector (1985-2010)

#### 3.2.8.2 Methodological issues

CO<sub>2</sub> emission from transport is calculated by multiplying fuel consumption taken from Energy Statistics Yearbooks (1985-2010) by the default IPCC emission factors.

Calculation of CH<sub>4</sub> and N<sub>2</sub>O emissions from road transport was changed a few years ago 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 and annual reports of Ministry of Economy and Transport about the Hungarian vehicle fleet (*Figure 3.16*).

For the base years it was assumed that passenger cars with 2-stroke engine have same 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 only after 1989. Since lead is poison for catalytic converters, therefore these catalytic converters could not work properly. It was assumed that real catalyst vehicle has been used after this time.

#### 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.

**Table 3.10.** CO<sub>2</sub> emission factors in the Transport Sector

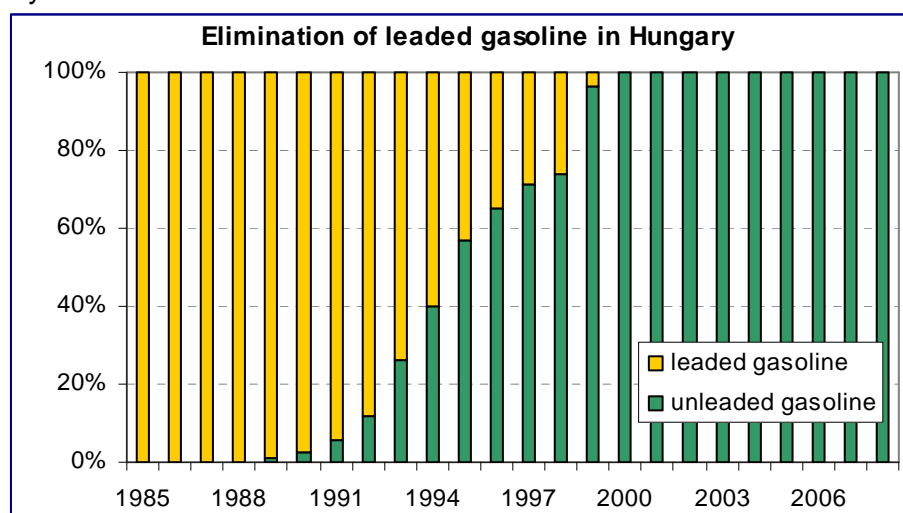
Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
Liquid fuels	Gasoline	18.9	Revised 1996 Guidelines, Table 1-2
	Gas/Diesel Oil	20.2	
	LPG	17.2	



Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
	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

Non-CO<sub>2</sub> emission factors for road transport 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<sub>2</sub>O 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 3.20.** Elimination of leaded gasoline in Hungary  
(Source: Hungarian Petroleum Association (MÁSZ), Annual Reports 1996-2008)

Methane and nitrous oxide emission factors for road transport are summarized in Table 3.12 and for railways and navigation are shown in the following table. 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.

**Table 3.11.** *CH<sub>4</sub> and N<sub>2</sub>O emission factors in the Transport Sector*

Category	Fuel type	Emission factor (kg/TJ)	
		CH <sub>4</sub>	N <sub>2</sub> O
Railways	Liquid fuels	5.0	0.6
	Solid fuels –Brown coal	10.0	1.4
Navigation	Gas/Diesel Oil	5.0	5.0 (0.6)
Civil aviation	Aviation Gasoline	0.5	2.0

*(excluding road transport)***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 stationary equipment because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is  $\pm 5\%$ . The estimated uncertainty of the emission factors for CO<sub>2</sub> is  $\pm 5-15\%$  for CH<sub>4</sub> is 50%, whereas that of N<sub>2</sub>O 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%).

**3.2.8.4 Source-specific QA/QC and verification**

None.

**Table 3.12.** CH<sub>4</sub> and N<sub>2</sub>O emission factors in the Road Transport Sector

Fuel type	Vehicle type	Emission control technology	Emission factor (kg/TJ)		Average fuel consumption (l/100km)	Source of EFs and average fuel consumption
			CH <sub>4</sub>	N <sub>2</sub> O		
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 performance 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 performance like heavy duty v.

*\* 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*

### 3.2.8.5 Source-specific recalculations

Time series of  $CH_4$  emission from natural gas as fuel was amended. For the sake of consistency, the default emission factor (92 kg  $CH_4$ /TJ) is used now for the entire time series. This recalculation, however, had an almost negligible effect on emissions with a maximum increase of 0.21 Gg expressed in  $CO_2$  eq.

### 3.2.8.6 Source-specific planned improvements

Its planned to compare the results of the COPERT model adapted for Hungarian circumstances with our currently used method.

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

### 3.2.9.1 Source category description

Emitted gases:  $CO_2$ ,  $CH_4$ ,  $N_2O$

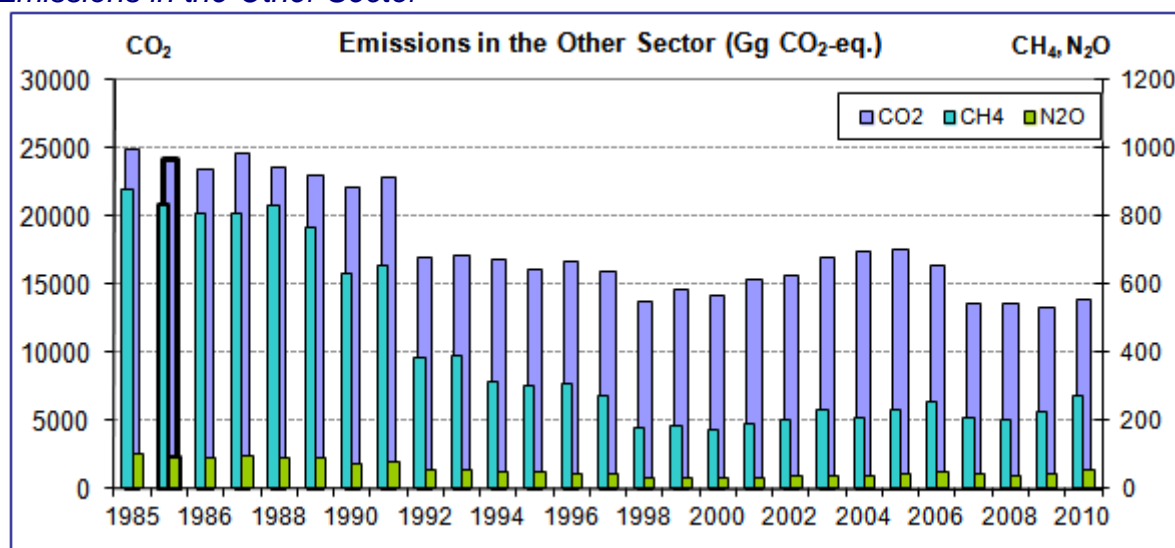
Methods: T1

Emission factors: D, CS

Key source: Level and Trend: Commercial/institutional,  $CO_2$ ; Residential,  $CO_2$ ; Agriculture/Forestry/Fisheries,  $CO_2$ , Trend: Residential  $CH_4$

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

### Emissions in the Other Sector

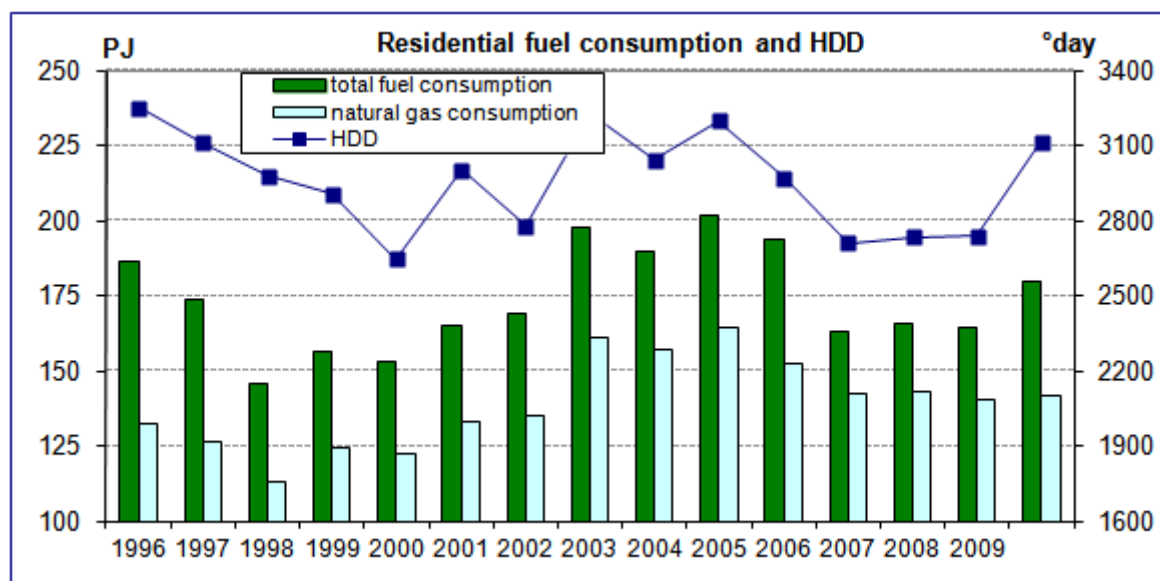


**Figure 3.21.** Trends of  $CO_2$ ,  $CH_4$  and  $N_2O$  emissions in the Other Sector (1985-2010)

### HDD and energy demand of the Residential Sector

Heating degree day (HDD) is a quantitative index which reflect demand for energy to heat houses and businesses. This index is derived from daily temperature observations. The inside temperature is  $18^{\circ}C$  and base temperature (the outside temperature above which a building needs no heating) is  $15^{\circ}C$  in our calculation (following the standard European

methodology). *Figure 3.22* illustrates the relationship between residential fuel consumption and HDD. Line of HDD and fuel consumption bars are running parallel, especially in the last 8-9 years.

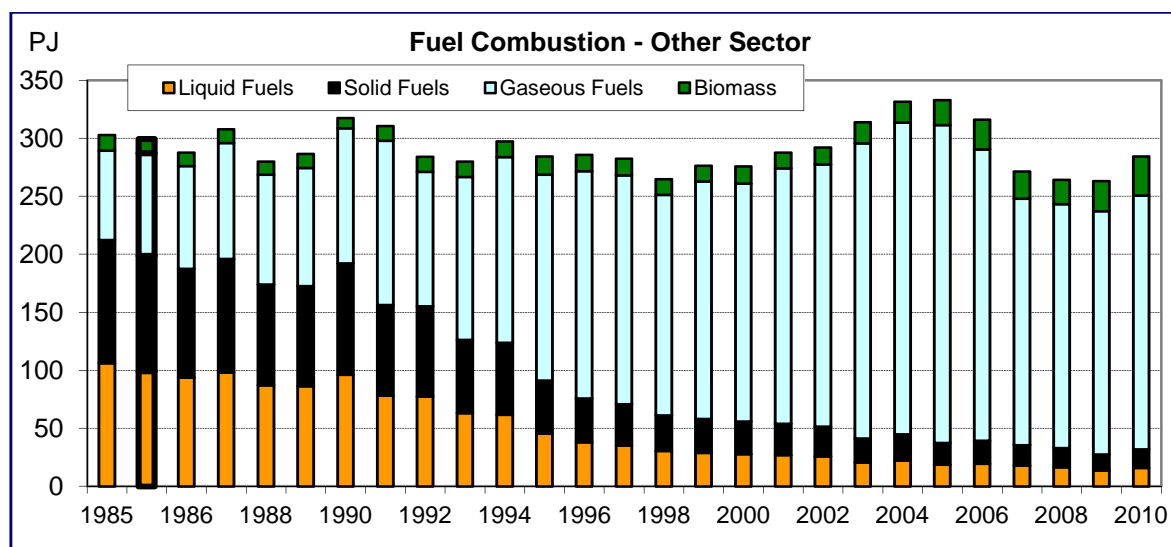


**Figure 3.22.** Comparison of residential fuel consumption and HDD between 1996 and 2010

### 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 3.23* illustrates the fuel consumption of the sector by types.



**Figure 3.23.** Share of different combusted fuel types in the Other Sector (1985-2009)

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. The dominance of natural gas, and the historical shift from liquid and solid fuels is clearly demonstrated by *Figure 3.23*. above. During the period 1985-2010 natural gas transmission

pipelines length had increased from 3544 km to 5782 km (see *Table 3.21.* . ),. The number of households supplied with natural gas has been increasing continuously, even in the last decade from 2.8 to 3.4 million. Population switched from coal to natural gas combustion. Household heating oil was completely replaced by LPG.

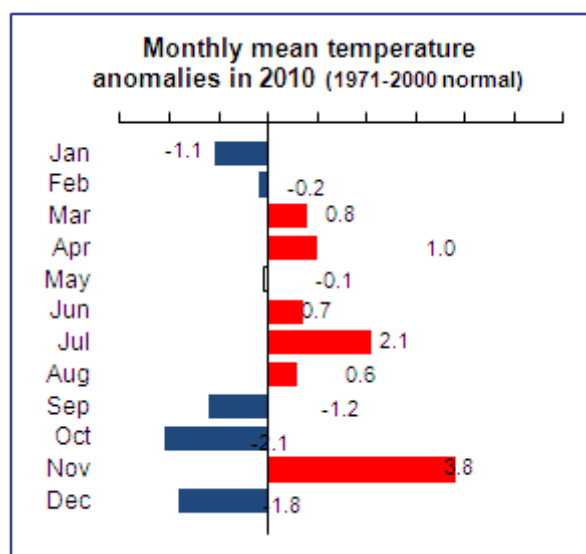
**Table 3.13.** *Oil and LPG consumption in the Commercial/Institutional and Residential Sectors in selected years after 2000*

Sector	Fuel consumption (TJ)	2000	2004	2005	2006	2007	2008	2009	2010
Commercial/ Institutional	Oil	1,127	744	289	41	325*	36*	0	0
	LPG	2,131	1,643	1,609	1,595	1,399	896	861	909
Residential	Oil	54	0	0	0	0	0	0	0
	LPG	12,091	8,836	6,688	6,890	3,943	3,673	3,351	4,415

\* 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, 2010).

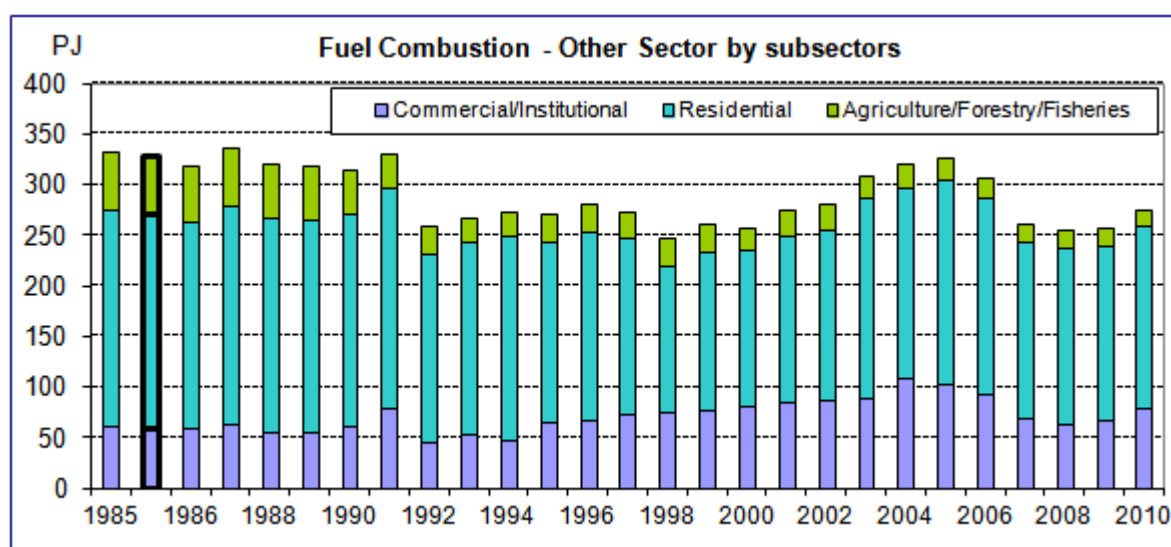
Residential consumption represented 38% of total piped gas supply in 2010. Piped gas is available in 91.2% of all settlements in Hungary. Some 85% of households use natural gas for heating purpose as well. Although individual residential heating became more and more widespread, still 648 thousand dwellings are supplied with district heating and 599 thousand with hot water. Most of this heat is generated from natural gas use, however, the resulting emission was not accounted for here but under the Energy industries subsector.



**Figure 3.24.** *Monthly mean temperature anomalies in 2009 (1971-2000 climatical average)*

Annual mean temperature was 0.2°C higher in 2010 compared to 1971-2000 climatical average and -1.1°C lower than in 2009. Despite of the very warm November, the heating period was also cooler than in 2010 which was reflected in the higher HDD value by 14% and also led to higher natural gas consumption. Nevertheless, the growth in natural gas use was quite moderate which is the joint impact of the following factors: more expensive tariff, modern heating systems and insulations. Steadily rising tariffs and the economic crisis is the main reason of growing biomass use in this sector as well.

The consumption rates of the subsectors are shown in *Figure 3.25.*



**Figure 3.25.** Fuel combustion in the subsector of the Other Sector (1985-2009)

### Emission factors

Default emission factors for CO<sub>2</sub> 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 3.2.6.2, 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<sub>2</sub> 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<sub>4</sub> are shown in Table 3.14. Default values were chosen to be used consistently, in line with Table I-7 of the 1996 IPCC Guidelines.

**Table 3.14.** Specific emission factors for CH<sub>4</sub> in the Other Sector

Emission Factors for CH <sub>4</sub> (kg/TJ)	Solid	Natural Gas	Liquid fuels	Wood
Commercial/Institutional	10	5	10	300
Residential	300	5	10	300
Agriculture	300	5	10	300

Similarly, default values from Table I-8 are used for N<sub>2</sub>O emission calculations with an exception for solid fuels where a bit higher factor was chosen (the same as in energy industries). These specific emission factors for N<sub>2</sub>O are shown in Table 3.15.

**Table 3.15.** Specific emission factors for N<sub>2</sub>O in the Other Sector

Emission Factors for N <sub>2</sub> O (kg/TJ)	Solid	Natural Gas	Diesel	LPG	Residual Fuel Oil	Wood
Commercial/Institutional	1.5	0.1	0.6	0.6	0.6	4.0
Residential	1.5	0.1	0.6	0.6	0.6	4.0
Agriculture	1.5	0.1	0.6	0.6	0.6	4.0



### 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  $\pm 10\%$ . The estimated uncertainty of the emission factors for  $\text{CH}_4$  is moderate ( $\pm 30\%$  to  $35\%$ ), whereas that of  $\text{N}_2\text{O}$  may be very high, i.e., 50% to 100%, as mentioned above.

### 3.2.9.4 Source-specific QA/QC and verification

None

### 3.2.9.5 Source-specific recalculations

Biomass consumption in residential category has been revised. For more details see chapter 10.2.4.

### 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 Fugitive emissions from solid fuels - (CRF sector 1.B.1)

##### 3.3.1.1 Source category description

Emitted gas: CH<sub>4</sub>

Methods: D, T2

Emission factors: CS

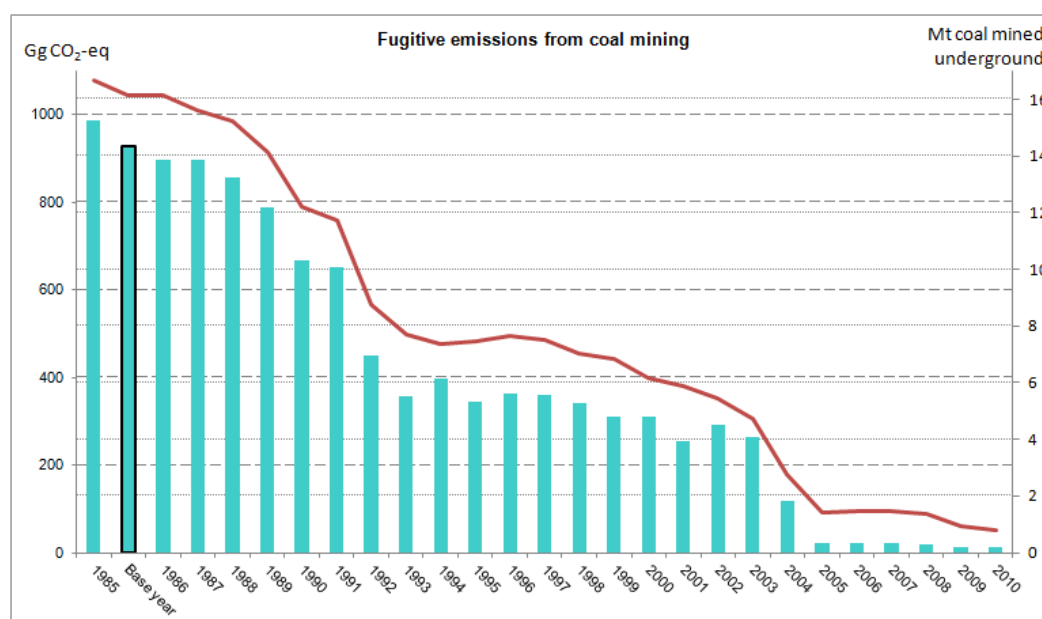
Key source: Trend: CH<sub>4</sub>

Category 1B1a includes fugitive CH<sub>4</sub> 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*).

Emissions from category 1B1b – Fugitive emissions originating from solid fuel transformation are included in sector 1A1c. The reason is that it is not possible to separate the GHG emissions from fugitive and non fugitive sources during coking, and there is no reference in any of the Guidebooks for emission estimation methodology in category 1B.

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 9% today. Drastic reduction in coal production was observed between 1987 and 1988, as well as between 1989 and 1990. Underground mining continues to decrease in both relative and absolute terms, therefore distribution of mined coal types underwent significant changes (see *Figure 3.27.*).

1B1a is a key category identified by TIER1 trend assessment. The significant decrease of the emissions is well explainable as the emissions are strongly related to activity data (production of coal mined underground). So, the fall of underground coal mining described in the paragraph before and presented in *Figure 3.26.* resulted the decreasing trend of emissions.



**Figure 3.26.** Trends of emissions from solid fuels (1985-2010)

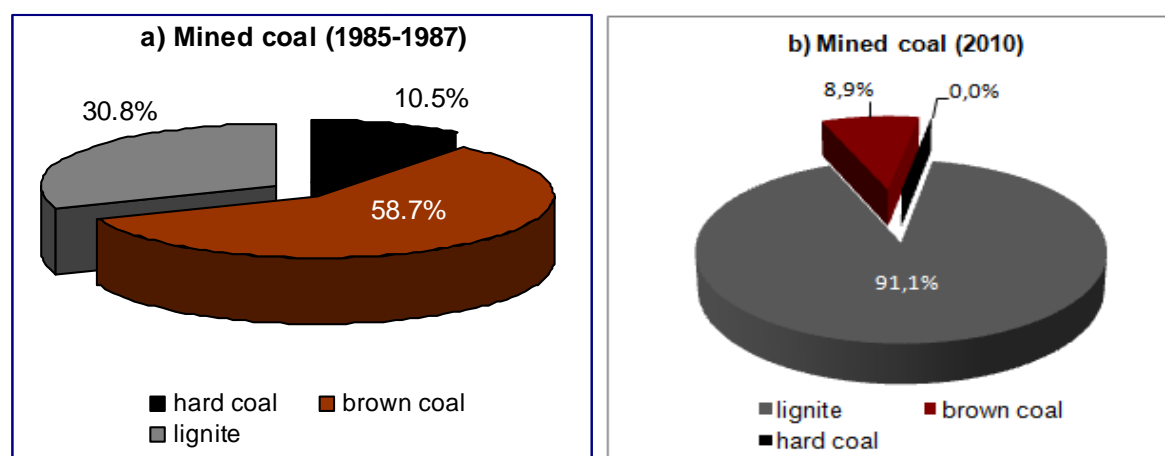
##### 3.3.1.2 Methodological issues

Emission calculations are based on detailed activity data (tree types of coal /underground or

surface mining). The actual CH<sub>4</sub> quantities released into the atmosphere are obtained by multiplying the data by the specific emission factors, which are calculated from mine specific measurement data

### Activity data

Production data were taken from the HCSO, Energy Statistics Yearbooks and IEA Coal statistics, and verified with data received from the Mining Bureau of Hungary. These statistical yearbooks provide the production of surface and underground mines together for each coal type.



**Figure 3.27.** Distribution of mined coal in the base year (a) and 2010 (b)

**Table 3.16.** Underground and surface coal mining in Hungary 1985-2010

	1985	1985-87	1986	1987	1988	1989	1990	1991	1992
Surface mining (Mt coal)	7.387	7.198	6.983	7.223	5.634	5.883	5.469	5.330	6.990
Underground mining (Mt coal)	16.655	16.141	16.146	15.621	15.241	14.147	12.192	11.730	8.760
Total indigenous production - Coal (Mt)	24.042	23.338	23.129	22.844	20.875	20.030	17.661	17.060	15.750
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Surface mining (Mt coal)	6.890	6.730	7.150	7.536	8.081	7.610	7.696	7.873	8.043
Underground mining (Mt coal)	7.720	7.380	7.438	7.654	7.508	7.040	6.851	6.160	5.871
Total indigenous production - Coal (Mt)	14.610	14.110	14.588	15.190	15.589	14.650	14.547	14.033	13.914
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Surface mining (Mt coal)	7.574	8.564	8.470	8.154	8.467	8.352	8.041	8.027	8.301
Underground mining (Mt coal)	5.453	4.737	2.772	1.416	1.485	1.466	1.363	0.959	0.812
Total indigenous production - Coal (Mt)	13.027	13.301	11.242	9.570	9.952	9.818	9.404	8.986	9.113

Table 3.16. shows the activity data used by the calculation of emissions in category 1.B.1.a. Amount of coal mined underground and in surface mines is detailed now as it was required in the last review report.

Hungarian mines are not drained nowadays. 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. 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 3.17 shows the measured methane content of coal for the mines operating between 1985 and 2005 in Hungary. Since 2006 the only one operating mine has been Márkushegy with 0.93 m<sup>3</sup>/t in-situ methane content, therefore its own measured data is used as emission factor (0,623 kg/t) after 2005 and the average by coal types before 2005. 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).

In Table 3.17 two columns are added in order to present the link between the measured data and the emission factor used. These are the average m<sup>3</sup>/t data by coal types and this data converted to [kg/t] (conversion factor is 0,67kg/m<sup>3</sup>, as it is suggested by the Guidebook).

**Table 3.17.. In-situ CH<sub>4</sub> content in Hungarian mines**

Coal type	Mine	In-situ CH <sub>4</sub> content (m <sup>3</sup> /t)		In situ CH <sub>4</sub> content (kg/t)
Hard coal	Pécsbánya – Karolina	18.26	19.5	13.06
	Vasas – Észak	20.75		
Brown coal	Balinka	1.29	1.00	0.67 <b>(0.623)</b>
	Lencsehegy	0.00		
	Mány I/a	0.98		
	<b>Márkushegy*</b>	<b>0.93*</b>		
Lignite	Bükkábrány	0.00	0	0
	Visonta	0.00		

\*the only mine operating since 2005 -(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. For mining activities emission factors were derived from measurement data in Hungary as it is presented in Table 3.18, while in case of post-mining emission factors were calculated as 10% of the value of mining factors as it is suggested by the GPG2000. The emission factors are lower than the default ones.

**Table 3.18. Comparison of IPCC default and country specific emission factors for coal mining**

Coal mining		Emission factor (kg CH <sub>4</sub> /t)	
		Default	Hungarian
Underground mining	Hard coal	6.700-16.750	13.065
	Brown coal		0.670 - 0.623*
Post-mining	Hard coal	0.603-2.680	1.340
	Brown coal		0.067- 0.0623*
Surface mining	Lignite	0.201-1.340	0.000
Post-mining		0.000-0.134	0.000

\* after 2005 only one mine has been operating and its in-situ methane content is known

As it was noted during the last review, IEF appearing in the CRF tables is unstable before

2005. The reason is that different emission factors are used for brown coal and hard coal, while the activity data reported in the CRF table is the total amount of coal mined underground. After 2005 there is only one mine operating, so the implied emission factor ( $0,623+0,0623=0,68541$  please see above) becomes steady.

### **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**

None.

### **3.3.1.5 Source-specific recalculations**

None.

### **3.3.1.6 Source-specific planned improvements**

The planned separation of brown coal and hard coal to underground and surface types is still not possible due to lack of information. However this improvement is assumed to cause a very small change.

In addition it is planned to include NMVOC emissions in order to be consistent with CLRTAP reporting.

## **3.3.2 Fugitive emissions from oil and natural gas activities (CRF sector 1.B.2)**

### **3.3.2.1 Source category description**

Emitted gas: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, indirect GHGs

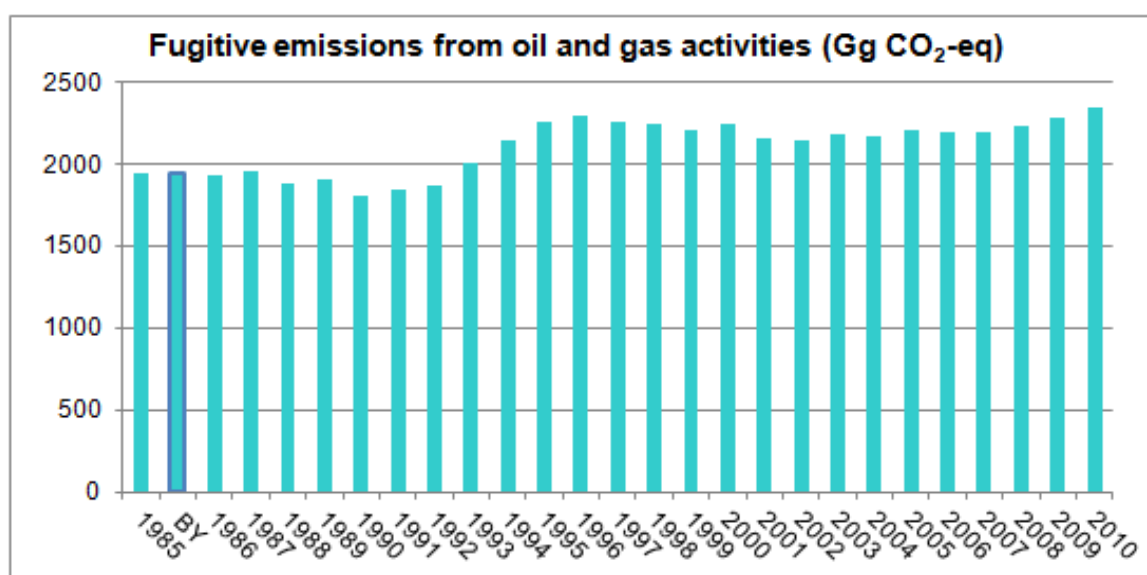
Methods: D, CS

Emission factors: D, CS, OTH

Key source: Level and Trend: CH<sub>4</sub>

In 1B2 category fugitive emissions arising during exploration, production, processing, transmission and distribution of Oil (1B2a) and Natural gas (1B2b) are reported and in a separate subcategory also GHG emissions from Venting and Flaring activities connected to the operations mentioned before (1B2c). In subcategory 1B2d -Other Hungary reports fugitive CH<sub>4</sub> emitted during extraction of thermal water and storage of Natural gas.

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.



**Figure 3.28.** Trends of emissions in CO<sub>2</sub> eq from oil and natural gas activities (1985-2010)

### 3.3.2.2 Methodological issues

Activity and consumption data related to extraction and primary handling were taken from Energy Statistics Yearbook and IEA Energy Statistics. 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 in 2003. This resulted fundamental changes 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. The emission factors presented in the Background paper are mostly the same as in GPG2000. Hungarian data for the activities indicated in this calculation were determined and multiplied by the provided specific emission factors.

CH<sub>4</sub>, CO<sub>2</sub> and N<sub>2</sub>O emissions from flaring (oil and gas) were included for the first time in 2009 submission, and as it was recommended during the review in 2010, CO<sub>2</sub> emissions from further subcategories were included in sector 1.B.2 this year. Please note that due to inclusion of further CO<sub>2</sub> emissions, recalculation was made in this sector, which is detailed in chapter 3.3.2.5. below.

All emissions included recently are also reported using default emission factors from GPG2000. The only exception is subcategory 1B2c2.1 – Oil refinery flaring, where EU ETS emission data of oil refinery flaring (reported directly by the company) is inserted too due to lack of emission factor.

Indirect greenhouse gases are reported solely in category 1B2a iv – Oil refinery.

The complete list of emission factors used in category 1.B.2 are presented in *Table 3.19.* and *Table 3.20.*

IPCC subsector code	Oli and Gas Activities (unit)	CH <sub>4</sub> emission factor	CO <sub>2</sub> emission factor	N <sub>2</sub> O emission factor	Source of emission factor
		(Gg/unit)	(Gg/unit)	(Gg/unit)	
1.B.2.a.i 1.B.2.b.i	Wells – Drilling (number)	$4.3 \cdot 10^{-7}$	NE	NA	IPCC - Background Papers, 2002 and GPG2000
	Wells – Testing (number)	$2.7 \cdot 10^{-4}$	NE	NE	IPCC - Background Papers, 2002 and GPG2000
	Wells – Servicing, (number)	$6.4 \cdot 10^{-5}$	NE	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.a.ii	Oil Production – Conventional (10 <sup>6</sup> m <sup>3</sup> )	$1.8 \cdot 10^{-3}$	<b><math>2.7 \cdot 10^{-4}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.a.iii	Oil Transport – Pipelines (10 <sup>6</sup> m <sup>3</sup> )	$5.4 \cdot 10^{-6}$	<b><math>4.9 \cdot 10^{-7}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
	Oil Transport – Tanker Trucks and Rail Cars (10 <sup>6</sup> m <sup>3</sup> )	$2.5 \cdot 10^{-5}$	<b><math>2.3 \cdot 10^{-6}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.a.iv	Oil refinery (GJ)	1400	NA	NA	IPCC 1996
1.B.2.b.ii	Gas Production (10 <sup>6</sup> m <sup>3</sup> )	$3.1 \cdot 10^{-3}$	<b><math>9.5 \cdot 10^{-5}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Sweet Gas Plants (10 <sup>6</sup> m <sup>3</sup> )	$7.1 \cdot 10^{-4}$	<b><math>2.7 \cdot 10^{-5}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Sour Gas Plants (10 <sup>6</sup> m <sup>3</sup> )	$2.4 \cdot 10^{-4}$	<b><math>2.9 \cdot 10^{-5}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Deep-cut Extraction Plants (10 <sup>6</sup> m <sup>3</sup> )	$7.2 \cdot 10^{-5}$	<b><math>3.0 \cdot 10^{-7}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.b.iii	Gas Transmission (km)	$3.4 \cdot 10^{-3}$	NE	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.b.iv	Gas Distribution (km)	$5.2 \cdot 10^{-4}$	NA	NA	IPCC - Background Papers, 2002 and GPG2000
	NGL Transport – Condensates and Pentanes Plus (10 <sup>6</sup> m <sup>3</sup> )	$1.1 \cdot 10^{-4}$	<b><math>7.2 \cdot 10^{-6}</math></b>	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.c.1.2	Gas Processing Venting – Raw CO <sub>2</sub> venting - Sour Gas Plants (10 <sup>6</sup> m <sup>3</sup> )	n.a	<b><math>7.1 \cdot 10^{-2}</math></b>	n.a.	IPCC - Background Papers, 2002 and GPG2000
1.B.2.c.2.1	Oil Production flaring – Conventional (10 <sup>6</sup> m <sup>3</sup> )	$2.5 \cdot 10^{-5}$	$6.7 \cdot 10^{-2}$	$6.4 \cdot 10^{-7}$	GPG 2000
1.B.2.c.2.2.	Gas Production flaring (10 <sup>6</sup> m <sup>3</sup> )	$1.1 \cdot 10^{-5}$	$1.8 \cdot 10^{-3}$	$2.1 \cdot 10^{-8}$	GPG 2000
	Gas Processing flaring – Sweet Gas Plants (10 <sup>6</sup> m <sup>3</sup> )	$1.3 \cdot 10^{-5}$	$2.1 \cdot 10^{-3}$	$2.5 \cdot 10^{-8}$	GPG 2000
	Gas Processing flaring – Sour Gas Plants (10 <sup>6</sup> m <sup>3</sup> )	$2.9 \cdot 10^{-5}$	$4.6 \cdot 10^{-3}$	$5.4 \cdot 10^{-8}$	GPG 2000
	Gas Processing flaring – Deep-cut Extraction Plants (10 <sup>6</sup> m <sup>3</sup> )	$6.2 \cdot 10^{-6}$	$9.7 \cdot 10^{-4}$	$1.2 \cdot 10^{-8}$	GPG 2000
1.B.2.d	Gas Storage (10 <sup>6</sup> m <sup>3</sup> )	$8.4 \cdot 10^{-4}$	NA	NA	GPG 2000

Note: emission factors included in reporting year 2012 are in bold



**Table 3.19..** Default emission factors used in 1B2 (previous page)

IPCC subsector code	Oli and Gas Activities (unit)	Emission factor
		kg/PJ
1.B.2.a.iv	Oil refinery NOx	0.0022
	Oil refinery CO	0.1735
	Oil refinery NMVOC	0.0172
	Oil refinery SO <sub>2</sub>	0.0283

**Table 3.20.** Emission factors used for the calculation of indirect GHGs and SO<sub>2</sub>

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 3.21.

Year	Pipeline length (km)										
	1985	1986	1987	1990	1995	2000	2005	2007	2008	2009	2010
Transmission	3,544	3,681	3,889	4,046	4,684	5,767	5,193	5,207	5,3	5,564	5,782
Distribution	10,262	12,474	14,2	22,559	53,436	72,54	80,519	81,555	82,128	82,565	82,884

**Table 3.21.** . Annual data for natural gas pipeline lengths in selected years

It is worth mentioning that IEF for fugitive CO<sub>2</sub> emissions of Natural Gas Production/Processing seems very unstable in CRF. The reason is that activity data for Natural Gas Production/Processing is Natural Gas Produced in PJ including all types (e.g.: Sweet Gas, Sour Gas). In fact CO<sub>2</sub> emissions are closely related to the amount of sour gas processed. The unit of measure of the Emission Factor is the sour gas processed in the case of Raw CO<sub>2</sub> venting, which is the main source.

### 3.3.2.3 Uncertainties and time-series consistency

The uncertainty of the majority of the activity data from recent years is favorable. 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.

Data of CO<sub>2</sub> emissions from oil refinery flaring reported under the 1.B.2.C.2.1 category have been available only since 2005, as EU ETS data is used, due to lack of emission factor in the Guidebook.

### 3.3.2.4 Source-specific QA/QC and verification

The inclusion of additional CO<sub>2</sub> emission reporting is documented in the required QA/QC registers as well. Emissions of indirect greenhouse gases and SO<sub>2</sub> reported in 1B2 significantly differ from the emissions reported in the relevant sector in CLTRAP reporting. To achieve consistency is a planned improvement.

### 3.3.2.5 Source-specific recalculations

Since 2010 submission CO<sub>2</sub> and N<sub>2</sub>O emissions from flaring have been reported based on default EF-s from Table 2-16 of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000). During the review process of year 2011 Hungary was encouraged to include other fugitive CO<sub>2</sub> sources from category Natural Gas and Oil.

In October 2011 recalculation was made to include CO<sub>2</sub> emissions originating from category Natural Gas Production/Processing based on default EF from Table 2 of Background Papers

for IPCC Expert Meeting on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Background Paper) This recalculation was again recalculated in January 2012 based on the EFs of GPG2000 for fugitive emissions and raw CO<sub>2</sub> venting. (The use of the factors of the GPG2000 for fugitive and flaring categories too are more accurate, since the use of the Background paper default EF-s in parallel with EF-s of GPG2000 for flaring leads to a significant overestimation of CO<sub>2</sub> emissions.)

In addition, fugitive CO<sub>2</sub> emissions are reported in category Oil production (Conventional Oil), Oil Transport and Condensates Transport as well. The same activity data is needed as for CH<sub>4</sub> emissions.

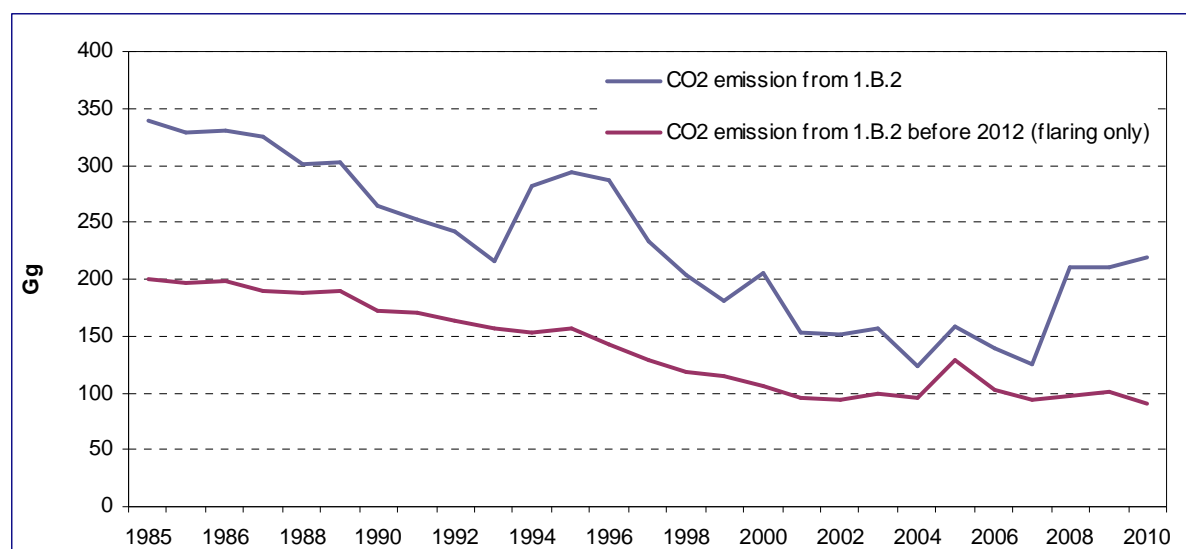
In subcategory 1.B.2.b.iv the reported AD was changed from gas consumed (PJ) to Natural Gas transmission pipelines (km) to have more stable IEF, as the latter is the unit of measure of the EF used.

In addition a mistype error for year 2007 in category 1.B.2.Biv Natural gas distribution CH<sub>4</sub> emission was corrected.

The notation key in subcategory 1.B.2.a.v. Distribution of oil products CO<sub>2</sub> and CH<sub>4</sub> was corrected to NA, because neither IPCC1996 nor GPG2000 do mention emission estimation methodology for 1.B.2.a.v.subsector, while IPCC2006 explicitly notes CO<sub>2</sub> and CH<sub>4</sub> emission as NA. Only NMVOC EF is provided in IPCC2006, which in fact seems the only notable emission source in the case of Distribution of Oil products.

	1991	1992	1993	1994	1995	1996	1997
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	252.69	241.58	215.46	282.29	293.07	287.71	232.69
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	169.82	163.93	155.90	153.55	157.08	141.97	128.89
<b>Difference</b>	82.87	77.65	59.56	128.74	135.99	145.75	103.80
<b>Percentage change %</b>	148.80	147.37	138.20	183.84	186.57	202.66	180.54
	1998	1999	2000	2001	2002	2003	2004
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	203.05	180.85	205.36	152.67	150.97	157.19	124.03
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	118.89	114.29	105.49	94.89	93.49	99.69	94.93
<b>Difference</b>	84.16	66.55	99.87	57.78	57.48	57.49	29.10
<b>Percentage change %</b>	170.79	158.23	194.67	160.89	161.48	157.67	130.65
	2005	2006	2007	2008	2009	2010	
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	158.48	139.77	125.50	210.73	209.62	218.96	
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	129.43	103.30	93.86	96.56	100.10	90.42	
<b>Difference</b>	29.06	36.47	31.64	114.17	109.52	128.53	
<b>Percentage change %</b>	122.45	135.30	133.71	218.24	209.42	242.15	

**Table 3.22.** Change in CO<sub>2</sub> emissions from Energy 1.B.2 sector due to recalculations



**Figure 3.29.** Difference of CO<sub>2</sub> emissions due to recalculation in sector 1.B.2

### 3.3.2.6 Source-specific planned improvements

Emissions of indirect GHGs are to be adjusted since new emission factors are available in EMEP/EEA Guidebook 2009. In this way the reporting will become consistent with CLRTAP reporting.

## 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

#### Underground storage and CH<sub>4</sub> emission from thermal water

Emitted gas: CH<sub>4</sub>

Methods: CS

Emission factors: OTH, CS

Key source: -

This category contains the emissions from underground storage of natural gas, 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

#### Underground storage

The methodology and emission factor were obtained from the previously mentioned IPCC Background Papers (2002), because the technology used in Hungary is entirely based on "Western" equipment. Emission factor is presented in Table 3.19. above. Activity data of this category is the annual mean of stored natural gas in exhausted reservoirs, it can be found in the online publication of the Hungarian Energy Agency.

#### CH<sub>4</sub> emission from thermal water

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<sub>4</sub> column

In this year annual amount of extracted thermal water as activity data for category 1.B.2.D Other CH<sub>4</sub> emission from thermal water was added, since it became available from HCSO statistics, although it seems a very rough estimation being the same amount for 2000-2010.

#### **3.3.3.3 Uncertainties and time-series consistency**

Since the emission of thermal water and other deep water drills is based on expert estimate, the uncertainty can be very high. According to the IPCC Good Practice Guidance (2000) the uncertainty of underground storage can be an order of magnitude.

#### **3.3.3.4 Source-specific QA/QC and verification**

None.

#### **3.3.3.5 Source-specific recalculations**

Activity data was added in this year.

#### **3.3.3.6 Source-specific planned improvements**

Although a roughly estimated activity data is now available for thermal water extraction, further improvements are still needed in this subsector regarding activity data and emission factor (or direct emission data) as well. Unfortunately new expert judgment or research results are still not available for HMS. Hopefully the utilization of CH<sub>4</sub> emitted during extraction of thermal water will spread and it will bring an improvement of emission estimation within this sector. Since this estimation is not explicitly required reporting element, the priority is given to other improvements.

### 3.4 References

Bihari, P., 1998: Energetics II. – university manuscript (In Hungarian: Energetika II., kézirat), *Budapesti Műszaki Egyetem*, Budapest.

Energy Centre, 2011: Energy Statistics Yearbook, 2010 (In Hungarian: Energiagazdálkodási Statisztikai Évkönyv, 2010), Budapest.

Intergovernmental Panel on Climate Change (IPCC), 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, *Intergovernmental Panel on Climate Change, Organisation for Economic Cooperation and Development, and International Energy Agency. (IPCC/OECD/IEA)*, UK Meteorological Office, Bracknell.

Available online at: <http://www.ipcc-nggip.iges.or.jp/public/ql/invs1.htm>

Intergovernmental Panel on Climate Change (IPCC), 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, *Intergovernmental Panel on Climate Change National Greenhouse Gas Inventories Programme*, Institute for Global Environmental Strategies, Japan.

Available online at: <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

Intergovernmental Panel on Climate Change (IPCC), Background Papers, 2002: IPCC Expert Meetings on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, p. 112., Japan.

(original source: CAPP, 1999: CH<sub>4</sub> and VOC Emissions from the Canadian Upstream Oil and Gas Industry, Vols. 1 and 2, Prepared for the Canadian Association of Petroleum Producers by Clearstone Engineering, Calgary, Alberta, Canada, Publication No. 1999-0010.)

Available online at: <http://www.ipcc-nggip.iges.or.jp/public/gp/gpg-bgp.htm>

Intergovernmental Panel on Climate Change (IPCC), 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, *Intergovernmental Panel on Climate Change National Greenhouse Gas Inventories Programme*, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: Institute for Global Environmental Strategies, Japan.

Központi Közlekedési Felügyelet, [http://www.trafipax.hu/index.php?akt\\_menu=116](http://www.trafipax.hu/index.php?akt_menu=116)

Hungarian Central Statistical Office (HCSO), 2010: Statistical yearbook of Hungary (In Hungarian: Magyar statisztikai évkönyv, 2010), Budapest.

Hungarian Central Statistical Office (HCSO), 2011: Infrastructural supply of settlements, 2010 (In Hungarian: A települések infrastrukturális ellátottsága, 2008). Statisztikai tükör, V., No. 75.

Közlekedéstudományi Intézet KHT. (KTI), 1997-2006: Determination of national, regional and local emission survey of the Hungarian road, rail, water-borne and air transport. (In Hungarian: A hazai közúti, vasúti, légi és vízi közlekedés országos, regionális és lokális emisszió-kataszterének meghatározása a 1995-2004-es évre vonatkozóan, 1997-2006) Prepared for the Ministry of Environment and Water.

Hungarian Petroleum Association (MÁSZ), 1996-2008: Annual Report

Delta Informatika Zrt, 2011: Visualization system for data on national road transport at end of 2010, Budapest.

Regional Centre for Energy Policy Research (Regionális Energiagazdasági Kutatóközpont – REKK) 2004: Projection of greenhouse gas emission in Hungary until 2012 based on economical research of significant emitters (In Hungarian: Magyarország üvegházgáz kibocsátásainak előrejelzése 2012-ig a jelentős kibocsátó ágazatok közgazdasági kutatása alapján), Budapest.

Magyar Villamos Művek Zrt. (MVM), 2009: Statistical Data of the Hungarian Power System 2008, ISSN 1788-2729 (online version).

[http://english.mvm.hu/resource.aspx?ResourceID=mvm\\_statisztika\\_web\\_gb\\_2008\\_20091110](http://english.mvm.hu/resource.aspx?ResourceID=mvm_statisztika_web_gb_2008_20091110)

Tajthy, T., 1994: Calculation of emission of air pollution substances (In Hungarian: A légekört szennyező anyagok kibocsátásának számítása), Technical University, Budapest.

## 4 INDUSTRIAL PROCESSES (CRF sector 2.)

### 4.1 Overview of sector

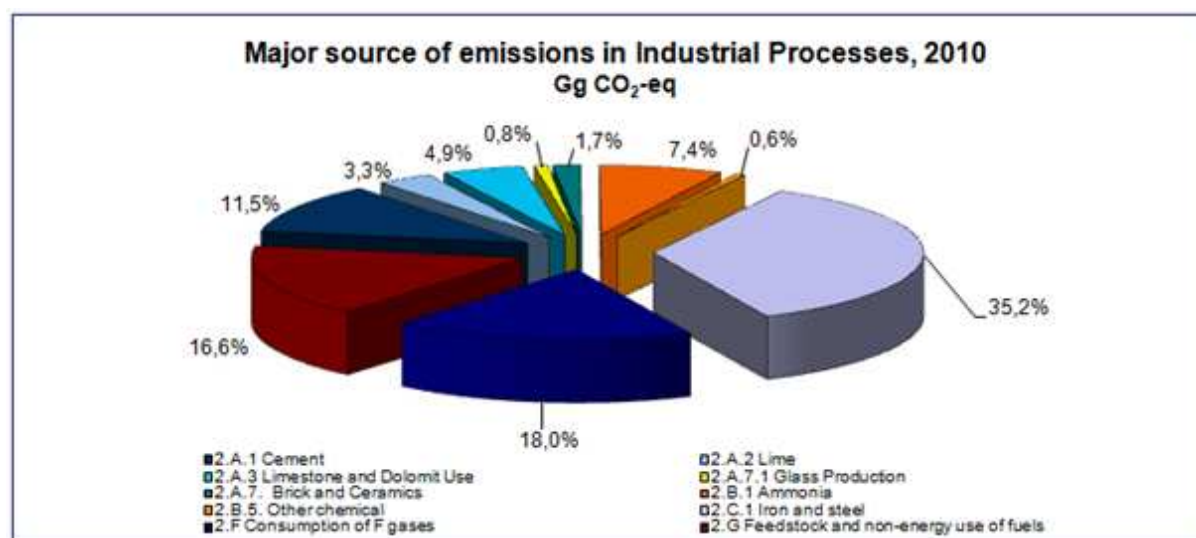
Industrial Processes sector includes emissions generated by non-firing processes related to industrial production. Emissions from the industrial processes are the third largest following the energy and agriculture sectors (see *Figure 2.7.* in Chapter 2).

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<sub>6</sub> (CRF 2.F.) and Other (CRF 2.G).

Under Mineral Products Hungary reports the emissions from cement production (CO<sub>2</sub>, SO<sub>2</sub>), lime production (CO<sub>2</sub>), limestone and dolomite use (CO<sub>2</sub>), asphalt production (CO, NMVOC), glass (CO<sub>2</sub>, NMVOC), bricks and ceramics production (CO<sub>2</sub>). Under Chemical Industry emissions from ammonia (CO<sub>2</sub>, CO, NMVOC, SO<sub>2</sub>), nitric acid (N<sub>2</sub>O, NO<sub>x</sub>, CO<sub>2</sub>), and other chemical production (CH<sub>4</sub>, NMVOC, SO<sub>2</sub>), for example carbon black and ethylene are reported. Under Metal Industry emissions from pig iron (CO<sub>2</sub>, CH<sub>4</sub>), steel (CO<sub>2</sub>, CH<sub>4</sub>) ferroalloys (CO<sub>2</sub>), aluminium (CO<sub>2</sub>, CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, NO<sub>x</sub>, CO, SO<sub>2</sub>) are taken into account. Consumption of halocarbons and SF<sub>6</sub> 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<sub>2</sub>).

The base year is the average of 1985–1987 for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, and 1995 for HFCs, PFCs and SF<sub>6</sub>.

*Figure 4.1* shows the main sources of greenhouse gas emissions:



**Figure 4.1.** The major processes in Industrial sector, 2010 (Gg, CO<sub>2</sub>-eq)

Several sub-sectors within Industrial Processes sector consist of emission originating from industrial facilities that are also falling under the scope of EU Emission Trading System (Directive 2003/87/EC). A short explanation of the EU Emission Trading Scheme can be found in Annex 2.2.

Although EU ETS data reported by the individual operators (summed together by industrial sector) would be probably more accurate than the use of default factors, its use in inventory preparation is very limited due to time series consistency problems. In 2010, in Industrial Processes sector EU ETS data is directly used solely in sector 2.A.1 Cement production, 2.A.7 Other mineral (Glass and Bricks and ceramics) and partly in 2.A.3 Limestone and dolomite use.



## 4.2 Emission Trends

Total emissions estimated from industrial processes were 6386.45 Gg CO<sub>2</sub>-eq in 2010, or 9.4% of the total national emissions compared to 12.8% in the base year. Total sectoral emissions decreased by 56.4% between the base year and 2010, and increased by 7.4% between 2009 and 2010.

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 until 2009 and aggregated emissions decreased by 41.0% between 2005 and 2009. 2010 has been the first year since 2005 when emissions increased again, as GHG emissions from industrial processes sector were 7.4% (400 Gg) higher in 2010 than in 2009.

Figure 4.2. shows the trend of GHG emissions from Industrial Processes by sub-categories for the years 1985 to 2010. The reallocation of emission from coke consumption in Iron and Steel industry from Energy sector to Industry sector performed in 2012 submission has changed the ranking and proportion of the sub-sectors within Industrial Processes compared to last years submissions.

Chemical industry was the most important emitter in the beginning of the inventory period, especially N<sub>2</sub>O emission from nitric acid production (for details see there). Between 1990 and 2005 Chemical industry, Mineral industry and Metal production were fluctuating around the same level. After the significant fall of emission in the Chemical Industry thank to the N<sub>2</sub>O abatement technology introduced in Nitric acid production in 2007, and the hard recession of the Mineral industry, Metal production took up the leading role. The growing tendency of Consumption of Halocarbons and SF<sub>6</sub> have also stopped in 2008. .

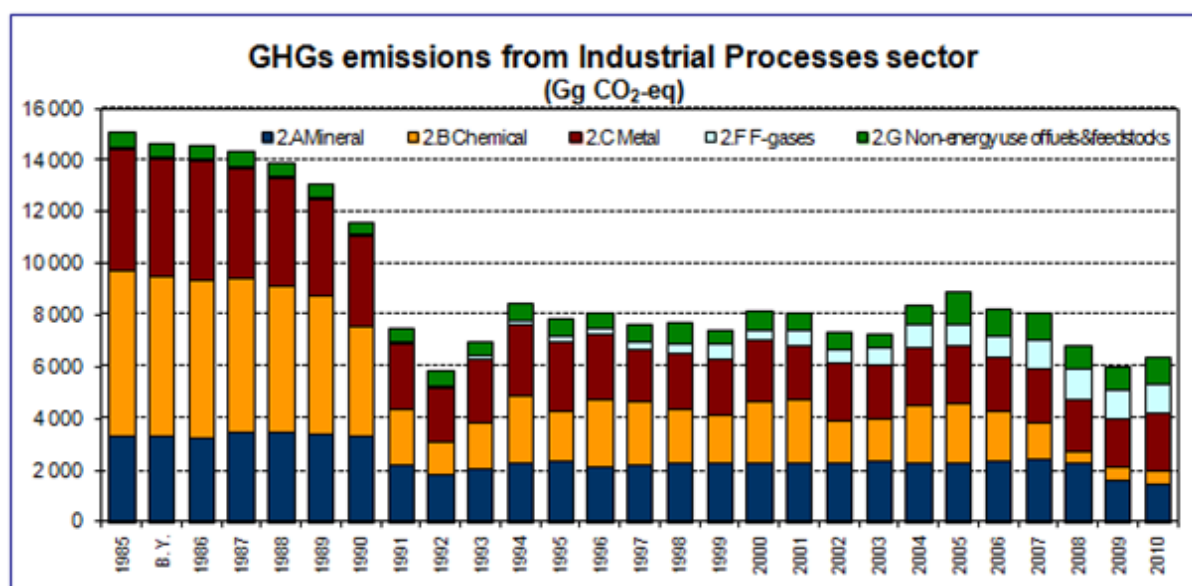


Figure 4.2. GHGs emissions from Industry sector, 1985-2010 (Gg CO<sub>2</sub>-eq)

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:

- 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;

- 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).

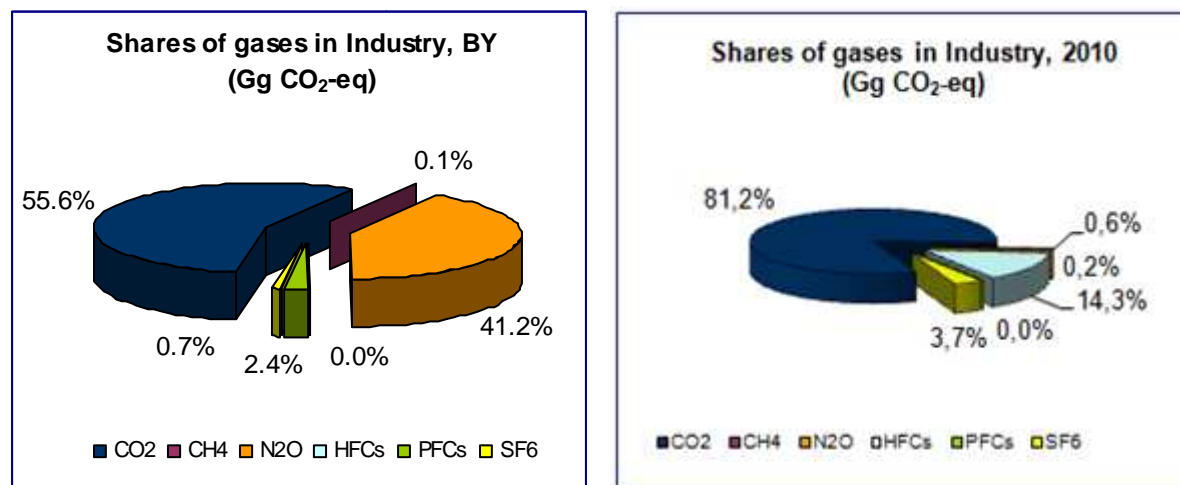
The privatization was slower in the industry than in other areas of the economy. Foreign investments were made rather in medium or smaller sized enterprises than in the big companies of the Hungarian industry.

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 favorable 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, 2009:566 kt, 2010:596 kt).

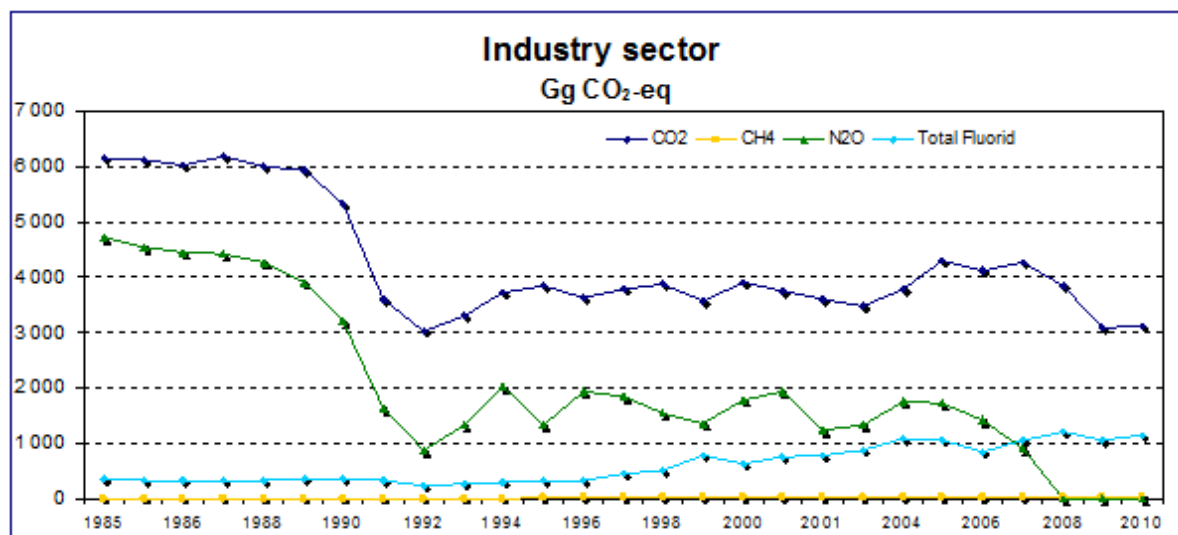
#### 4.2.1 Emission Trends by Gases

The most important GHG in Industrial Processes sector is carbon dioxide, contributing 81.2% to total GHG emissions in this sector in 2010, followed by hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>) contributing 18.0% to GHG emissions CH<sub>4</sub> and N<sub>2</sub>O contributed 0.6% and 0.2%, respectively (*Figure 4.3*). Total sectoral emissions decreased by 56.4% between base year and 2010.



**Figure 4.3.** Shares of gases in Industry sector, in base year and 2010 (Gg CO<sub>2</sub>-eq)

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



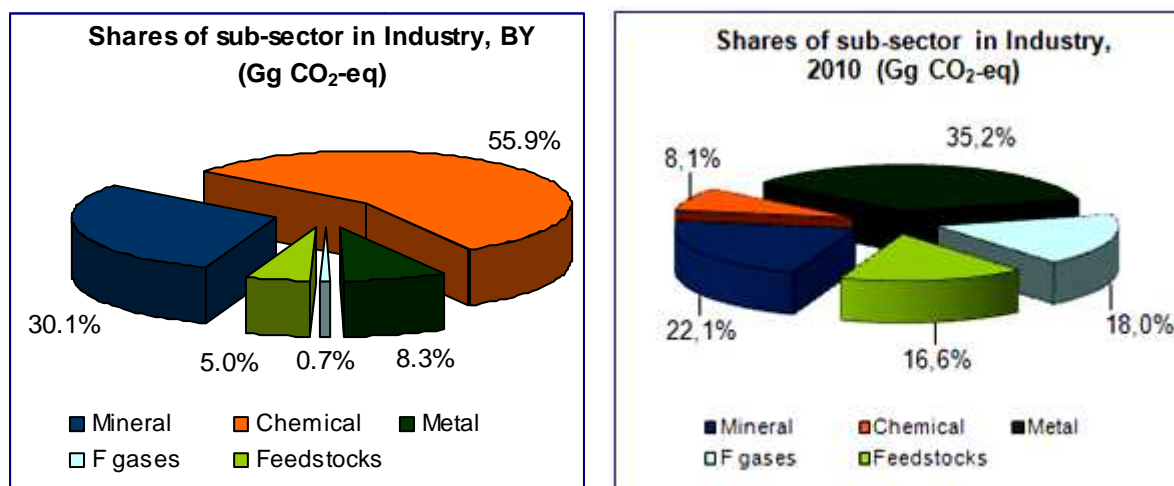
**Figure 4.4.** The most significant greenhouse gases in Industry sector.

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

It can be seen in *Figure 4.4* that in 2008, N<sub>2</sub>O 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 55.9% of total industrial GHG emissions, followed by mineral sub-sector 30.1%, metal sub-sector 8.3%, feedstocks and non energy use of fuels 5.0% and F-gases 0.7%. In 2010 metal sub-sector accounted for 35.2% and mineral sub-sector 22.1% followed by F-gases 18.0%, feedstocks and non energy use of fuels 16.6%, chemical sub-sector 8.1% (see *Figure 4.5* and *Table 4.1*).



**Figure 4.5.** Shares of sub-sectors in Industry sector, in base year and 2010 (Gg CO<sub>2</sub>-eq)

**Table 4.1.** Emissions of Industrial processes sector in 2010, (CO<sub>2</sub>-eq)

GHG emissions in 2010 (Gg CO <sub>2</sub> -eq)					
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC/PFC/SF <sub>6</sub>	Total
<b>2. Industrial Processes</b>	<b>5186.67</b>	<b>39.59</b>	<b>10.64</b>	<b>1149.55</b>	<b>6386.46</b>
A. Mineral products	1412.58	0.00	0.00	0.00	1412.58

GHG emissions in 2010 (Gg CO <sub>2</sub> -eq)					
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC/PFC/SF <sub>6</sub>	Total
B. Chemical Industry	470.55	35.15	10.64	0.00	516.35
C. Metal Production	2242.87	4.44	0.00	0.00	2247.31
D. Other Production	0.00	0.00	0.00	0.00	0.00
E. Production of HFC/PFC/SF <sub>6</sub>	0.00	0.00	0.00	0.00	0.00
F. Consumption of HFC/PFC/SF <sub>6</sub>	0.00	0.00	0.00	1149.55	1149.55
G. Other	1060.66	0.00	0.00	0.00	1060.66

### 4.3 Mineral Products (CRF sector 2.A)

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

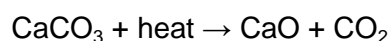
##### 4.3.1.1 Source category description

Emitted gas: CO<sub>2</sub>, SO<sub>2</sub>

Key source: Level and Trend: Cement production, CO<sub>2</sub>

CO<sub>2</sub> 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<sub>3</sub>) fed into the furnace, which occurs at around 1,300°C and results in CaO (Calcium Oxide) and CO<sub>2</sub> (calcinations).



The raw materials may contain other carbonate minerals (e.g., MgCO<sub>3</sub>). 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.

In this sector the emission estimation methodologies are very similar in the case of IPCC and EU ETS (Methodology of EU ETS reporting is prescribed in Annex VII of 589/2007/EC Monitoring and Reporting Guidelines). The basis of emissions factors for cement production is the same in fact, as all uses the stoichiometric ratio of the above mentioned equation as follows:

$g \text{ CO}_2 / g \text{ CaCO}_3 = 44/100 = 0,44$  (default EU ETS Kiln input based method, HU country specific method)

$g \text{ CO}_2 / g \text{ MgCO}_3 = 44/84 = 0,52$  (default EU ETS Kiln input based method, HU country specific method)

$g \text{ CO}_2 / g \text{ CaO} = 44/56 = 0,785$  (default IPCC1996 and EU ETS Clinker output based method)

$g \text{ CO}_2 / g \text{ MgO} = 44/40 = 1,019$

(C:12 g/M; O:16 g/M; Ca:40 g/M; Mg:24 g/M)

The differences between the methods may arise therefore just from the accuracy of data of the carbonate content of the raw flour and/or the Ca/Mg oxide content of the clinker. In addition MgCO<sub>3</sub> content and CKD (cement kiln dust) should be taken into account. In the case of the most detailed method, the carbon content of other raw materials or additives and the carbon content of the output material are also considered.

For the first time this year CO<sub>2</sub> emissions from cement production is also identified as key

category in trend assessment thank to the notable negative trend of the emissions compared to the base year. Significant decrease of emissions have occurred in this sector since 2008. The decrease of emissions correlates with the decrease of activity data. Activity data is reported directly by the cement producer companies and verified with the data of HCSO. The decrease of activity data can be explained by decrease of the production, due to the continuous recession of this industrial sector. In building industry the recession is still ongoing and there was no recovery in 2010 unlike several other industrial segments in Hungary. The producing facilities are struggling to survive, which is published also on their website and reflected in volume indices (NACE Rev.2 classes CG- 2351 Manufacture of cement - Volume index of industrial gross output, corresponding period of the previous year= 100 (per cent): 2009: 79.1; 2010: 75.9).

#### 4.3.1.2 Methodological issues

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 2009 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<sub>2</sub> emission. This value is calculated on the basis of the derivatographic analysis of carbonate, which contains also CO<sub>2</sub> generated from the MgCO<sub>3</sub> content of limestone. All these increase the accuracy of emission-determination. The reported quantities of CO<sub>2</sub> emitted between 2005 and 2010 are based on reports of the factories.

This is in fact the same emission estimation methodology at plant level as before at country level, because for the preceding years, also raw material consumption was used for emission calculation (kiln input based method and the permanent stoichiometric ratios detailed above) instead of cement or clinker production. This is more accurate because cement factories have always measured 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 (1985-2010)

	1985	B Y	1986	1987	1988	1989	1990	1991	1992
<b>Raw, kt</b>	5,044.1	5,151.8	4,981.6	5,429.6	5,263.7	5,338.2	5,148.0	3,247.3	2,533.2
<b>Clinker, kt</b>	3,097.9	3,173.2	3,069.5	3,352.1	3,250.5	3,320.7	3,210.4	2,067.3	1,591.3
<b>Cement, kt</b>	3,670.8	3,888.9	3,845.2	4,150.8	3,871.4	3,856.8	3,932.8	2,563.2	2,245.6
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Raw, kt</b>	3,009.6	3,476.5	3,493.0	3,274.8	3,463.0	3,603.0	3,617.2	3,998.1	4,008.5
<b>Clinker, kt</b>	1,906.7	2,211.0	2,214.2	2,034.0	2,184.8	2,262.1	2,270.6	2,531.8	2,522.0
<b>Cement, kt</b>	2,521.3	2,795.3	2,874.9	2,745.0	2,806.2	2,995.1	2,979.1	3,348.2	3,452.4
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Raw, kt</b>	4,218.3	4,209.1	3,828.2	3,578.8	3,884.3	3,938.7	3,747.0	2,889.3	2,181.2
<b>Clinker, kt</b>	2,687.1	2,696.1	2,494.8	2,352.6	2,533.1	2,577.1	2,468.4	1,883.0	1,433.2
<b>Cement, kt</b>	3,504.2	3,564.9	3,266.7	3,363.5	3,722.9	3,485.1	3,569.8	2,808.5	2,133.9

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<sub>2</sub> was calculated using the proper stoichiometric proportions. On a similar way we calculated also the amount of CO<sub>2</sub> generated from MgCO<sub>3</sub> 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<sub>2</sub> emission in 2.A.1 Cement Production sub-sector (1985-2010)

	1985	B Y	1986	1987	1988	1989	1990	1991	1992
CO <sub>2</sub> from CaCO <sub>3</sub> , kt	1,686.9	1,724.0	1,667.4	1,817.6	1,790.2	1,811.5	1,752.1	1,098.0	857.2
CO <sub>2</sub> from MgCO <sub>3</sub> , kt	54.5	54.3	52.2	56.2	51.9	49.8	45.2	28.5	26.5
Total CO <sub>2</sub> , kt	1,741.4	1,778.3	1,719.6	1,873.8	1,842.2	1,861.4	1,797.3	1,126.5	883.7
	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO <sub>2</sub> from CaCO <sub>3</sub> , kt	1,019.6	1,178.3	1,182.9	1,108.6	1,171.8	1,216.7	1,221.6	1,353.9	1,365.0
CO <sub>2</sub> from MgCO <sub>3</sub> , kt	31.5	36.2	35.9	34.8	36.2	36.4	37.7	41.0	42.7
Total CO <sub>2</sub> , kt	1,051.1	1,214.6	1,218.8	1,143.3	1,208.0	1,253.1	1,259.4	1,395.0	1,407.6
	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO <sub>2</sub> from CaCO <sub>3</sub> , kt	1,434.8	1,404.8	1,291.0	1,198.9	1,295.9	1,328.1	1,260.6	972.7	735.4
CO <sub>2</sub> from MgCO <sub>3</sub> , kt	42.4	47.5	49.6						
Total CO <sub>2</sub> , kt	1,477.2	1,452.4	1,340.6	1,198.9	1,295.9	1,328.1	1,260.6	972.7	735.4

Due to the CO<sub>2</sub> generated from MgCO<sub>3</sub>, 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<sub>3</sub>. 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<sub>3</sub>. The MgCO<sub>3</sub> 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<sub>2</sub> emissions calculated for the individual factories and production data. These are shown in the table below. In addition, the table above demonstrates the time series of the annual emissions<sup>1</sup>:

**Table 4.4.** Specific emission factors of clinker and cement in 2.A.1 Cement Production sub-sector (1985-2010)

	1985	B Y	1986	1987	1988	1989	1990	1991	1992
CO <sub>2</sub> / clinker	0.5621	0.5604	0.5602	0.5590	0.5667	0.5605	0.5598	0.5449	0.5553
CO <sub>2</sub> / cement	0.4744	0.4573	0.4472	0.4514	0.4758	0.4826	0.4570	0.4395	0.3935
	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO <sub>2</sub> / clinker	0.5513	0.5493	0.5505	0.5621	0.5529	0.5539	0.5546	0.5510	0.5581
CO <sub>2</sub> / cement	0.4169	0.4345	0.4239	0.4165	0.4305	0.4184	0.4227	0.4166	0.4077

<sup>1</sup>The national total emission was calculated by summing the emissions of individual factories instead of using the average of the specific emissions.



	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO <sub>2</sub> / clinker	0.5498	0.5387	0.5374	0.5096	0.5116	0.5153	0.5107	0.5166	0.5131
CO <sub>2</sub> / cement	0.4216	0.4074	0.4104	0.3565	0.3481	0.3811	0.3531	0.3463	0.3446

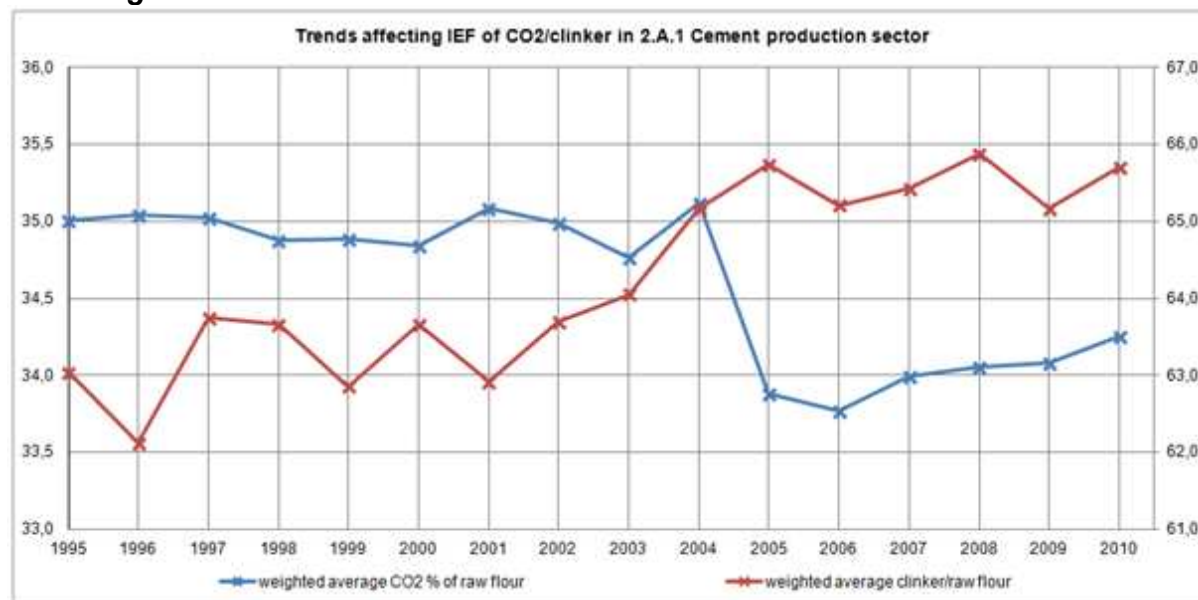
The default factor is 0.5071 t/t for clinker (with a CaO content of 65%), and 0.4985 for cement (Revised Guidelines). The higher specific CO<sub>2</sub> emission of clinker is due to the higher CaCO<sub>3</sub> content of raw flour which results in better clinker quality. This enables the higher content of additives in cement and lower emission factors.

The review report of the last year drew the attention to the decrease of IEF of t CO<sub>2</sub>/ t clinker between 2003-4 and 2005.

The change to the use of ETS data from 2005 does not affect the calculation methodology in fact (as both before and after the kiln input based method was used with the same stoichiometric ratios as it is described above in sub-chapter 4.4.3.1). So, the change probably can be attributed on one hand to the change of the carbon content reported by the companies. The following diagram presents the trend of the weighted average carbon content reported by the companies either to ETS competent authority or directly to HMS. The decrease might be caused by the change of composition of raw materials used, or by the improvement of measurement methods of the laboratories. It is assumed that the data after 2005 is more accurate since in EU ETS accredited laboratories are to be used. It is also justified by the fact that the IEF after 2005 is nearer to the default IEF(0.5071 t CO<sub>2</sub> /t clinker).

As the CO<sub>2</sub> emission is calculated from the raw flour, also the clinker/raw flour proportion may affect the IEF of CO<sub>2</sub>/ clinker. Therefore the diagram also consist the trend of the clinker/raw flour proportion. However in this regard a continuous change is notable from the beginning of the last decade. IPCC default clinker / raw flour proportion is: 64,6 % (Revised IPCC1996 Guidelines Reference Manual Section 2.3.2).

**Figure 4.6.** Trend of carbon content of raw flour and trend of clinker/ raw flour



Note1: The trends before 1995 are quite steady.

#### 4.3.1.3 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 <sup>2</sup> :	2.5 %

The originally small uncertainty was further improved by using data of Emission Trade System.

As the country specific method is mainly the same as the emission reporting methodology of the EU ETS, the time series is more consistent this way, than it would be in the case of the use of Tier1 or Tier2 method of the IPCC Guidelines. As the use of ETS data means the use of verified data, where the carbon contents should be measured in accredited laboratory (or at least a laboratory yearly validated and inter-compared with accredited laboratory as it is prescribed in section 13.5 of Annex I of 589/2007/EC), we believe that the use of ETS data improves the accuracy of the data reported in the inventory.

#### 4.3.1.4 Source-specific QA/QC information and verification

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 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<sub>3</sub> content of the CKD.

#### 4.3.1.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.3.1.6 Source-specific planned improvements

None.

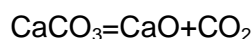
### 4.3.2 Lime Production (CRF Sector 2.A.2)

#### 4.3.2.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: NO

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



<sup>2</sup> Taking into consideration that although the highest uncertainty is associated with CKD, it affects a negligible proportion of the production volume.

Here, only CO<sub>2</sub> is generated according to this formula. CO<sub>2</sub> generated by firing processes is accounted under the Energy sector in Manufacturing Industries and Construction (1.A.2.B).

#### 4.3.2.2 Methodological issues

The amount of CO<sub>2</sub> 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)<sub>2</sub>) production data as well.

#### 4.3.2.3 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.

#### 4.3.2.4 Source-specific QA/QC information and verification

The activity data were received directly from the operators which increased the reliability of the information. Since 2005 also EU ETS data have been available. At the moment EU ETS data is used only for verification purpose in order to avoid time series consistency problem caused by the 4-8% difference.

**Table 4.5. CO<sub>2</sub> emission comparison, Gg**

CO <sub>2</sub> emissions, (Gg)	2005	2006	2007	2008	2009	2010
Factories with T1 EF, Gg	323.137	303.849	300.752	318.497	205.983	211.280
EU-ETS data (Gg)	298.521	285.987	277.399	303.879	197.285	199.625
Difference, Gg	24.615	17.862	23.353	14.618	8.698	11.655
Difference, %	8.25	6.25	8.42	4.81	4.41	5.84

#### 4.3.2.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.3.2.6 Source-specific planned improvements

None.

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

#### 4.3.3.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: NO

This sub-sector includes processes in which calcinations (CO<sub>2</sub> loss) occur as a result of heating limestone and dolomite, but excluding their use in cement and lime production and liming of soils. Here, only CO<sub>2</sub> emissions generated by the degradation reaction are calculated while gases from fuel combustion are included in sub-sector 1.A.2.B.

#### 4.3.3.2 Methodological issues

The emissions were calculated according to the Revised Guidelines using the correct stoichiometric ratios as emission factors (440 kg CO<sub>2</sub> / ton limestone and 477 kg CO<sub>2</sub>/ ton

dolomite, along with the default factor for fraction of purity of 1).. Only limestone and dolomite used during various phases of iron production and limestone quantities used during flue gas desulphurization are calculated here.

Activity data of the limestone and dolomite used in iron and steel industry 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 mentioned in chapter 2.13.3.1 of IPCC1996 Revised Guidelines) was used.

Flue gas desulphurization has been carried out in one power plant since 2002 and in another one since 2004. Activity data on the use of carbonates for SO<sub>2</sub> scrubbing is either reported by the operators directly to the HMS or to EU ETS competent authority (In EU ETS the operators are required to report CO<sub>2</sub> emission from the use of carbonate for scrubbing separately in their annual emission report).

#### **4.3.3.3 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.

#### **4.3.3.4 Source-specific QA/QC information and verification**

No sector-specific information is available.

#### **4.3.3.5 Source-specific recalculations**

Last year there was no recalculation.

#### **4.3.3.6 Source-specific planned improvements**

None.

### ***4.3.4 Asphalt roofing (CRF sector 2.A.5.) and Road paving with asphalt (CRF sector 2.A.6.)***

#### **4.3.4.1 Source category description**

Emitted gas: NMVOC, CO

Solely indirect GHGs are the significant process emissions within these sectors.

#### **4.3.4.2 Methodological issues**

In sector 2.A.5 Asphalt roofing NMVOC and CO emissions and in sector 2.A.6 Road paving with asphalt solely NMVOC emission are reported. Activity data is taken from HCSO and European Asphalt Pavement Association and default emission factors are from the Revised IPCC1996 Guidebook.

#### **4.3.4.3 Source-specific QA/QC information and verification**

No sector-specific information is available.

#### **4.3.4.4 Source-specific recalculations**

None.

#### **4.3.4.5 Source-specific planned improvements**

Review of EFs is planned based on the latest available EMEP/EEA Guidebook.

### 4.3.5 Glass Production (CRF sector 2.A.7.1)

#### 4.3.5.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: NO

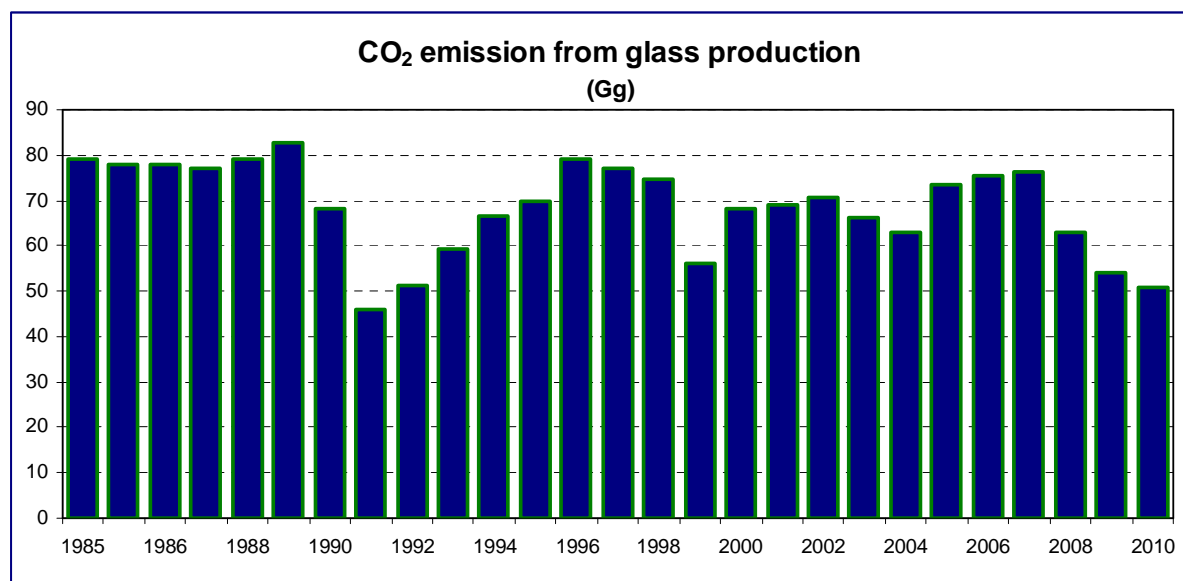
Although glass production is mentioned in the Revised Guidelines as a source of NMVOC only, also CO<sub>2</sub> emission from glass production was determined based on the data from the Emission Trading System. CO<sub>2</sub> emission is generated by adding the carbonates (mainly soda ashes) of the alkali metals (Ba, Li, Na, etc.) to the melt in the course of glass melting.

#### 4.3.5.2 Methodological issues

Considering the fact that all the glass factories take part in the emission trade, the quantity of CO<sub>2</sub> reported by them was accepted as emissions between 2005 and 2010. The data of total produced quantity were provided by the HCSO. The CO<sub>2</sub> emission is only 50.69 Gg representing only 0.1% of the total CO<sub>2</sub> 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 4.7* below shows the complete CO<sub>2</sub> emission from this category:



**Figure 4.7.** CO<sub>2</sub> emission from Glass Production (1985-2010)

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<sub>2</sub> emission from ETS data with the emissions calculated with our country-specific factor and we have received the following results (*Table 4.6*):

**Table 4.6.** CO<sub>2</sub> emission comparison, Gg

	2006	2007	2008	2009	2010
CO <sub>2</sub> emission from ETS, Gg	75.275	76.147	62.980	53.970	50.694
CO <sub>2</sub> emission using country-specific IEF-2005, Gg	68.050	71.781	73.593	65.985	64.733
Difference, Gg	7.225	4.366	-10.612	-12.015	-14.040
Difference, %	10.62	6.08	-14.42	-18.21	-21.69

CO<sub>2</sub> emission from ETS was higher in 2006 and 2007 by 10.62% and 6.08%, respectively but lower in 2008, 2009 and 2010 by 14.42%, by 18.21% and by 21.69%. The lower value was due to the new data logging methodology of the HCSO, i.e. estimations were made from salesmanship. So, as it was also stated by the review report of last year, please note that for 2008 onwards the activity data are proxy data only and, thus, the IEFs are not comparable with those of previous years.

#### 4.3.5.3 Source-specific QA/QC information and verification

No sector-specific information is available.

#### 4.3.5.4 Source-specific recalculations

Last year there was no recalculation.

#### 4.3.5.5 Source-specific planned improvements

None.

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

#### 4.3.6.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: NO

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<sub>2</sub> 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.

#### 4.3.6.2 Methodological issues

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<sub>2</sub> 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 2010 was 105.5 Gg which is 0.2 % of the total CO<sub>2</sub> emission. The following table contains the data of production and emission:

**Table 4.7.** Bricks and ceramics production and CO<sub>2</sub> emission in Industry sector (1985-2010)

	1985	B.Y.	1986	1987	1988	1989	1990	1991	1992
Bricks and ceramics, kt	6,623.2	6,339.6	5,998.6	6,397.0	6,522.9	6,104.1	6,275.8	4,509.4	3,500.9
CO <sub>2</sub> Gg	587.9	536.6	532.5	567.8	579.0	541.8	557.1	400.3	310.8

	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Bricks and ceramics, kt</b>	3,978.9	4,207.6	4,784.3	4,217.0	4,222.7	4,437.6	4,162.3	3,021.9	2,728.3
<b>CO<sub>2</sub> Gg</b>	353.2	373.5	424.7	374.3	374.8	393.9	369.5	268.2	242.2
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Bricks and ceramics, kt</b>	2,300.4	3,018.6	3,277.1	3,763.0	3,817.0	4,841.0	4,026.6	1,482.6	1,450.8
<b>CO<sub>2</sub> Gg</b>	204.2	267.9	290.9	334.0	360.5	357.6	312.0	110.2	105.5

#### 4.3.6.3 Uncertainties and time-series consistency

The estimation of uncertainties is based on the uncertainty of EU ETS data. In EU ETS uncertainty of the activity data and/or the overall emissions has to be ensured by the operators at a level prescribed in the GHG emission permit. This is usually less than 7.5% (see 589/2007/EC Decision on the the monitoring and reporting of greenhouse gas emissions).

The years before 2005 in the time series are calculated by the application of an emission factor calculated based on the 2005 EU ETS data.

#### 4.3.6.4 Source-specific QA/QC information and verification

No sector-specific information is available.

#### 4.3.6.5 Source-specific recalculations

Activity data has been changed in submission year 2012. Activity data on total production of bricks and ceramics is provided by the HCSO every year. In 2008 HCSO switched from NACE1. to NACE2.2. classification of industrial products. It was discovered that due to this change the activity data in 2009 was incomplete and did not cover the full domestic production. This correction does not cause a change in emissions, since anyway ETS data is used in this sector but the IEF of CO<sub>2</sub> has changed significantly to a better fitting value, as it is presented in Table 4.8. Activity data change is presented in Table 4.9.

**Table 4.8.** Change in CO<sub>2</sub> IEF (t/t) in Bricks and ceramics(2.A.7 –Other Mineral Products) sector

	2008	2009
<b>Submission 2011</b>	0.10529	0.17708
<b>Submission 2012</b>	0.07747	0.07432
<b>Difference</b>	-0.03	-0.10
<b>Percentage change</b>	-26.4%	-58.0%

**Table 4.9.** Change in activity data (kt) in Bricks and ceramics(2.A.7 –Other Mineral Products) sector

	2008	2009
<b>Submission 2011</b>	2,962.756	622.224
<b>Submission 2012</b>	4,026.644	1,482.639
<b>Difference</b>	1,063.89	860.42
<b>Percentage change</b>	35.9%	138.3%

#### 4.3.6.6 Source-specific planned improvements

None

### 4.4 Chemical Industry (CRF sector 2.B)

The relevant processes operated in Hungary include:

- Ammonia production
- Nitric acid production
- Production of other chemicals: carbon black, ethylene and dichloroethylene.

Production of the chemical industry increased in 2010 compared to 2009 by 9.15%. This is demonstrated by the time series of the production data in the tables shown later and in the next figure.

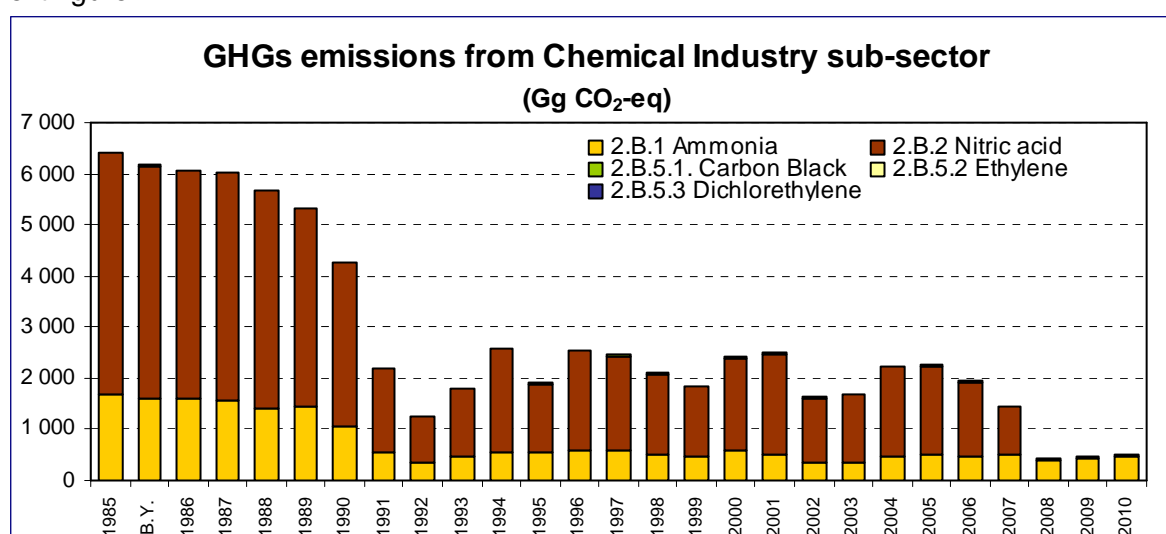


Figure 4.8. Total emission from Chemical sub-sector (1985-2010)

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

##### 4.4.1.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: Level and Trend: ammonia production, CO<sub>2</sub>

Traditional ammonia (NH<sub>3</sub>) 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.AA.2.C. We followed the IPCC Guidelines as regards carbon emission factor for natural gas (15.3 t C/TJ), and we calculate with 34 TJ/Mm<sup>3</sup> natural gas consistently for the whole time series

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<sub>2</sub>, because hydrogen is bought and not produced there. During the review of the last year the ERT recommended to clarify where the hydrogen is produced and where the emissions are reported if produced inland. The issue is under investigation at the moment and the results will be included in next year's submission. However it seems that in the case hydrogen production is present, the emissions are reported already. The question is



just to separate (and reallocate) the hydrogen production emissions from the Natural gas used in the Energy sector and/or from 2.G Feedstock and non energy use of fuels.

The share of hydrogen/ nitrogen based ammonia production within all ammonia production is about only 5 %. 95% of ammonia production is “traditional” natural gas based.

#### 4.4.1.2 Methodological issues

Initially, production data published by KSH and default value recommended by the Revised Guidelines (1.5 to CO<sub>2</sub>/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. The operator reports the amount of Natural gas used as feedstock separately from the Natural gas used for combustion.

According to the recommendation of ERT in 2007, we indicated the natural gas quantity instead of the previously used ammonia production in the CRF Reporter. Since the input of the natural gas quantity in cubic meters 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 4.10.** Amount of natural gas used in the process, CO<sub>2</sub> emission and IEF tCO<sub>2</sub>/tNH<sub>3</sub> in Chemical sub-sector (1985-2010)

	1985	BY	1986	1987	1988	1989	1990	1991	1992
<b>Natural gas, kt</b>	685.86	661.26	651.80	646.13	574.42	585.67	432.05	230.34	148.92
<b>CO<sub>2</sub>, Gg</b>	1 676.33	1 616.22	1 593.09	1 579.23	1 403.97	1 431.46	1 056.00	562.97	363.97
<b>IEF CO<sub>2</sub> (t/tNH<sub>3</sub>)</b>	1.76	1.71	1.71	1.65	1.63	1.67	1.67	1.59	1.61
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Natural gas, kt</b>	186.69	222.47	223.70	247.69	237.39	212.17	191.94	241.86	212.31
<b>CO<sub>2</sub>, Gg</b>	456.30	543.74	546.74	605.39	580.21	518.56	469.13	591.14	518.92
<b>IEF CO<sub>2</sub> (t/tNH<sub>3</sub>)</b>	1.57	1.49	1.45	1.43	1.41	1.48	1.48	1.38	1.32
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Natural gas, kt</b>	144.30	143.54	184.74	208.03	195.59	213.77	160.91	177.01	192.52
<b>CO<sub>2</sub>, Gg</b>	352.70	350.84	451.52	508.44	478.05	522.47	393.28	432.63	470.55
<b>IEF CO<sub>2</sub> (t/tNH<sub>3</sub>)</b>	1.32	1.34	1.29	1.28	1.29	1.28	1.34	1.28	1.29

The Table 4.10 above indicates that tCO<sub>2</sub>/tNH<sub>3</sub> IEF value is between 1.28 and 1.76.

#### 4.4.1.3 Uncertainties 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.

#### 4.4.1.4 Source-specific QA/QC information and verification

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

#### 4.4.1.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.4.1.6 Source-specific planned improvements

Investigation of the issue of hydrogen production, and reallocation of process emissions if relevant.

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

#### 4.4.2.1 Source category description

Emitted gas:  $\text{N}_2\text{O}$ , ( $\text{CO}_2$ )

Key source: Trend: Nitric acid production,  $\text{N}_2\text{O}$

Nitric acid ( $\text{HNO}_3$ ) is produced by oxidizing ammonia. The process end gas contains  $\text{N}_2\text{O}$  and  $\text{NO}_x$ . 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.

In 1985 3 plants operated with 9 unit. Among the old factories using obsolete technologies, one was abandoned in 1988, another in 1991, and a third in 1995. Until 2007 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). *Figure 4.9* shows the operating nitric acid plant between 1985 and 2010.

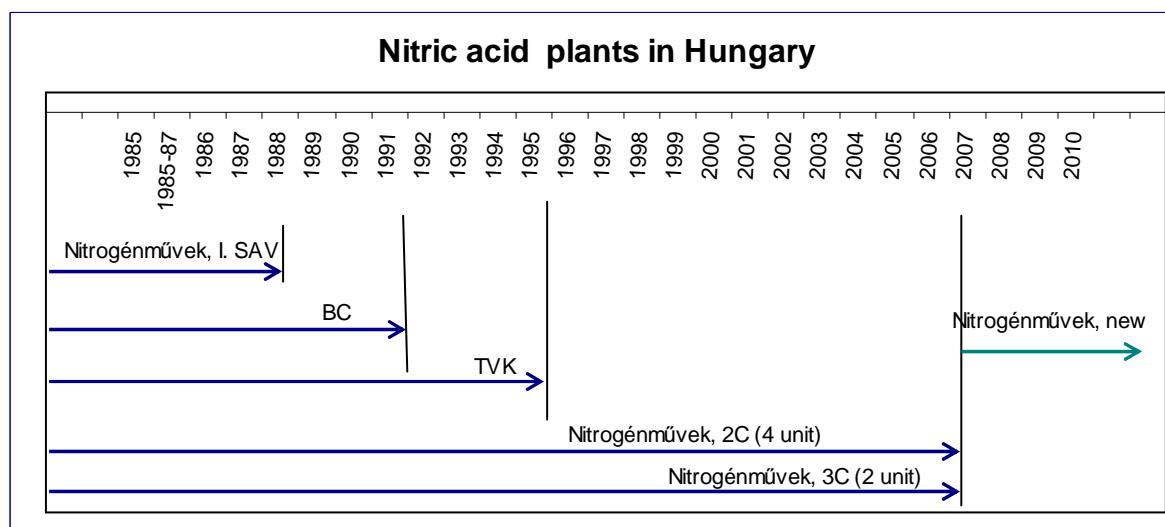


Figure 4.9. Nitric acid plants in Hungary, 1985-2010

Implementation of a new and more advanced production technology was started in 2005, in the framework of a joint implementation project (one of the a flexible mechanism facilitated by the Kyoto Protocol), 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 4.11*).

The verification of this fact is possible thanks to the publicly available information published in the Joint Implementation project documentation:

<http://ji.unfccc.int/JIITLProject/DB/GSZRV07J6MCQRD8BAZ3MN839PHNZE5/details>

In the JI documentation of this project the following performance data can be found:

[http://klima.kvvm.hu/documents/116/Nitrog\\_nm\\_vekZrt\\_ves\\_jelent\\_s2008publikus.pdf](http://klima.kvvm.hu/documents/116/Nitrog_nm_vekZrt_ves_jelent_s2008publikus.pdf)

#### 4.4.2.2 Methodological issues

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<sub>2</sub>O/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. N<sub>2</sub>O meter is placed after the catalyst which measures emissions continuously. The regular monitoring report is based on daily average measurement data but the system is capable to provide data for shorter time period, e.g. hourly averages. The factory makes available its measured data to the inventory compiler.

The requirements of the set up and functioning of the continuous measurement system is prescribed in the IPPC (Integrated Pollution Prevention and Control) permit of the installation, as the plant is falling under the scope of the IPPC Directive (Directive 2008/1/EC). IPPC Directive in general is implemented in the Hungarian law by the 314/2006. Government Decree and further requirements on the set up and functioning of continuous emission measurement systems is regulated by 6/2011. (I.14.) Ministerial Decree. The IPPC permit is issued, updated and enforced by the competent authority (Inspectorate for Environment, Nature and Water).

In addition the facility is also falling under the scope of E-PRTR Regulation (Regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register). This means that on one hand data can be verified with data reported in E-PRTR (as all E-PRTR data is available to the public on <http://prtr.ec.europa.eu/FacilityLevels.aspx>), on the other hand the E-PRTR Regulation require also to use internationally recognized measurement standards.


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<sub>2</sub>O/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 was 6.15 kg/t , 0.0425 kg/t in 2008, 0.108 kg/t in 2009 and 0.0715 kg/t in 2010. The new factory applies the EnviNOx technology consequently a drastic reduction of emission has been reached. N<sub>2</sub>O emission from nitric acid production was decreased by 99% between base year and 2009.

ATTACHMENT 1

PERFORMANCE TEST RUN SHEET

01-1418-600

Uhde	PERFORMANCE TEST RUN EnviNOx® NZRT						
DESIGNATION	UNIT	GUARANTEED	ACHIEVED				
			DAY 1	DAY 2	DAY 3	AVERAGE	
N <sub>2</sub> O-REDUCTION IN TAIL GAS	%	min. 94 ( initially)	99.63	99.64	99.63	99.63	
NO <sub>x</sub> CONCENTRATION IN TAIL GAS DOWNSTREAM ENVI NOx® SYSTEM	ppm vol.	max. 25	5.7	5.6	5.7	5.7	
NH <sub>3</sub> CONCENTRATION IN TAIL GAS DOWNSTREAM ENVI NOx® SYSTEM	ppm vol.	max. 5	Laboratory 0.19 AI0808 3.4	Laboratory 0.47 AI0808 3.3	Laboratory 0.57 AI0808 3.3	0.41 3.3	
NH <sub>3</sub> CONSUMPTION IN ENVI NOx® SYSTEM	mol NH <sub>3</sub> / mol NO <sub>x</sub>	max. 2.2	1.36	1.36	1.36	1.36	
NATURAL GAS HYDRO- CARBON CONSUMPTION IN ENVI NOx® SYSTEM	mol H.C. / mol N <sub>2</sub> O	max. 0.2	0.077	0.078	0.077	0.077	

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<sub>2</sub> 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 26 years in the time series. These and the emission data are shown in the table below:

**Table 4.11. Nitric Acid production (kt) and N<sub>2</sub>O emission in Chemical sub-sector (1985-2010)**

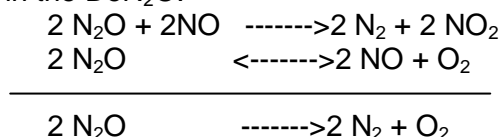
	1985	BY	1986	1987	1988	1989	1990	1991	1992
<b>Nitric Acid, kt</b>	1,051.48	1,013.09	994.80	992.98	965.19	891.48	732.35	377.47	210.55
<b>N<sub>2</sub>O, Gg</b>	15.256	14.650	14.415	14.279	13.745	12.568	10.368	5.240	2.868
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Nitric Acid, kt</b>	310.34	460.11	310.28	453.83	433.53	354.44	309.50	415.99	454.27
<b>N<sub>2</sub>O, Gg</b>	4.336	6.558	4.347	6.211	5.982	5.022	4.399	5.795	6.293
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Nitric Acid, kt</b>	294.80	306.21	415.01	484.41	460.83	474.91	385.96	440.01	480.53
<b>N<sub>2</sub>O, Gg</b>	4.044	4.272	5.701	5.593	4.612	2.922	0.016	0.048	0.034

### EnviNOx technology

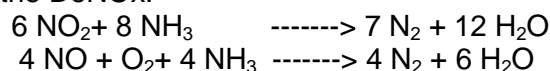
The EnviNOx process is usually located between the final tail gas heater and the tail gas turbine and contains two catalyst beds filled with iron zeolite catalysts operating at the same pressure and temperature and a device for addition NH<sub>3</sub> between the beds. In the first DeN<sub>2</sub>O stage, the N<sub>2</sub>O abatement is effected simply by the catalytic decomposition of N<sub>2</sub>O into N<sub>2</sub> and O<sub>2</sub>. Since NO<sub>x</sub> content of the tail gas promotes the decomposition of N<sub>2</sub>O, the required DeNO<sub>x</sub> stage is arranged downstream of the DeN<sub>2</sub>O stage.

In the second stage, NO<sub>x</sub> reduction is carried out using NH<sub>3</sub> as a reducing agent similar to natural gas.

Reactions in the DeN<sub>2</sub>O:



Reactions in the DeNO<sub>x</sub>:



For a short description of the used technology please check this site:

[http://www.uhde.eu/fileadmin/documents/brochures/uhde\\_brochures\\_pdf\\_en\\_5000028.pdf](http://www.uhde.eu/fileadmin/documents/brochures/uhde_brochures_pdf_en_5000028.pdf)

#### 4.4.2.3 Uncertainties 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 favorable, i.e., between about 30-40 %, however, this value is estimated to decrease to about 10% by 2005 due to direct measurements.

#### 4.4.2.4 Source-specific QA/QC information and verification

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).

#### 4.4.2.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.4.2.6 Source-specific planned improvements

None.

### 4.4.3 Carbon Black (CRF sector 2.B.5.1)

#### 4.4.3.1 Source category description

Emitted gas: CH<sub>4</sub>

Key source: NO

#### 4.4.3.2 Methodological issues

Their contribution to the total emission is extremely low. 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<sub>4</sub>/t product, in 2010 ERT recommended the use of default factor, which is 11 kg CH<sub>4</sub>/t carbon black.

#### 4.4.3.3 Source-specific QA/QC information and verification

No sector-specific information is available.

#### 4.4.3.4 Source-specific recalculations

Last year there was no recalculation.

#### 4.4.3.5 Source-specific planned improvements

None.

### 4.4.4 Other chemicals (CRF sector 2.B.5)

#### 4.4.4.1 Source category description

Emitted gas: CH<sub>4</sub>, NMVOC

Key source: NO

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

- Ethylene: 1 kg CH<sub>4</sub>/t ethylene
- Dichloroethylene: 0.4 kg CH<sub>4</sub>/t dichloroethylene

#### 4.4.4.2 Methodological issues

Their contribution to the total emission is extremely low. Therefore, they are dealt with as one group. Using production data obtained from KSH and default values recommended by IPCC, methane emission was calculated for these two processes. In 2010, this value was only 1.67 Gg (0.04 %). Comparing to the data of the previous years (0.34 - 1.52 Gg), the effect of production increase by ~37% in 2010 can be observed here as well.

CO<sub>2</sub> emission from ethylene production is reported in sector 2.G – Feedstock and non-energy use of fuels. In sector 2.G emissions are reported in an aggregated way and they are calculated by feedstock (not by industrial process type), therefore it is not possible to present CO<sub>2</sub> emission of ethylene production separately.

Ethylene may be produced from several kinds of feedstock. In Hungary it is produced mainly from naphta, as far as our knowledge. As all type of feedstock are reported in 2.G sector, the inclusion of CO<sub>2</sub> emissions from ethylene production is assured irrespectively of the type of feedstock used by ethylene production.

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 2010, these emissions amounted to 8.38 Gg.

#### 4.4.4.3 Source-specific QA/QC information and verification

No sector-specific information is available.

#### 4.4.4.4 Source-specific recalculations

There was no recalculation, just the notation key of CO<sub>2</sub> emissions from ethylene production is changed to IE, based on the recommendation of the review report of last year. CO<sub>2</sub> emission from ethylene production has always been reported in fact in sector 2.G, as ethylene is produced from fuels used as feedstock, but it was not noted in this sector before.

#### 4.4.4.5 Source-specific planned improvements

In the case of indirect GHGs it is planned to use EF from EMEP/EEA 2009 Guidebook in order to reach consistency with CLRTAP reporting.



## 4.5 Metal Production (CRF sector 2.C)

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

#### 4.5.1.1 Source category description

Emitted gas: CO<sub>2</sub>

Key source: Level and Trend: CO<sub>2</sub>

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<sub>2</sub>. Therefore, CO<sub>2</sub> 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<sub>2</sub>.

Basic oxygen furnace (BOF also known as LD converter) technology for production of steel uses the hot, molten pig iron with scrap iron, additives and quicklime. Electric arc furnace (EAF) technology uses mainly scrap iron with additives and the heat is provided by electric arc formed between graphite electrodes. The consumption of graphite electrodes results CO<sub>2</sub> emission as well.

In Hungary, all the activities connected to iron and steel industry are present: production of coke, sintering, production of pig iron and production of steel using basic oxygen furnace (BOF) and electric arc furnace (EAF) technology too. Except for the EAF steel production, all the activities mentioned before are located in one single plant, which is however operated by different operators, so it can not be regarded an integrated iron and steel plant.

#### 4.5.1.2 Methodological issues

Earlier only the emissions from carbon content reduction of the input materials during steel production and the emission from the consumption of graphite electrodes (2.C.1.1. subsector) were reported within this sector and all the other emissions were included elsewhere.

In 2012 a major reallocation between sector 1.A.2.a and 2.C.1.2 (Pig Iron production) and 2.C.1.4 (Coke consumption) was performed after the recommendation of the review report of submission 2011 and also the subsector 2.C.1.1 (Steel) was recalculated.

In the following table the present allocation of emissions connected to Iron and steel production is summarized. The changes introduced in 2012 are noted in bold.

**Table 4.12.** Allocation of emissions connected to Iron and steel production

IPCC sector code	Activity	Emission source	2011 submission -Emission reported in	2012 submission -Emission reported in
1.A.1.c	Production of coke	combustion	1.A.1.c	<b>1.A.1.c (including coke oven gas)</b>



IPCC sector code	Activity	Emission source	2011 submission -Emission reported in	2012 submission -Emission reported in
1.A.2.a	Combustion needed for iron and steel production	combustion	1.A.2.a	1.A.2.a (including coke oven gas)
2.C.1.3	Sinter	Metal roasting	Included in 1.A.2.a	Included in 2.C.1.1
		limestone and dolomite use	Included in 2.A.3	Included in 2.A.3
2.C.1.2	Pig Iron	Combustion	Included in 1.A.2.a	Included in 1.A.2.a
		<b>Consumption of coke</b>	<b>Included in 1.A.2.a</b>	<b>Included in 2.C.1.4</b>
		<b>Consumption of Natural gas for non-energy purposes</b>	<b>Included in 1.A.2.a</b>	<b>2.C.1.2</b>
		limestone and dolomite use	Included in 2.A.3	IE to 2.A.3
2.C.1.4	Consumption of coke	<b>Consumption of coke in the blast furnace</b>	<b>Included in 1.A.2.a</b>	<b>2.C.1.4.</b>
2.C.1.1	Steel	reduction of carbon content (from 4% to 0,5%)	2.C.1.1.	2.C.1.1.
		emission from graphite electrode during EAF steel production	2.C.1.1.	2.C.1.1.

All cell comment of IE cells in CRF tables have also been updated accordingly.

Due to the reallocation performed this year this category was also identified as key both in the case of level and trend assessment.

#### Emission factors

Default emission factors from the IPCC1996 Guidelines are used.

In the case of consumption of coke and natural gas, both CO<sub>2</sub> and CH<sub>4</sub> emissions are reported using kg /TJ default factors from the energy sector in order to achieve more accurate results by using actual NCV data of the year. So, instead of the use of 3,1 ton CO<sub>2</sub> / t reducing agent default EF given in Table 2-12 of IPCC1996, it is more accurate to use the actual TJ data combined with EF given in energy sector (107.7 t CO<sub>2</sub> / TJ). The EF of 3,1 t CO<sub>2</sub> / t reducing agent is anyway derived from the 108,76 t CO<sub>2</sub> / TJ EF using a default net calorific value for the coke.

#### Activity data

Iron and steel production data were obtained from the reports of the International Iron and Steel Institute, World Steel Association (WORLDSTEEL) and the similar European agency (EUROFER).

Data on Consumption of coke and natural gas in the blast furnace is extracted from the IEA Energy Statistics of Hungary.

#### 4.5.1.3 Steel ( CRF sector 2.C.1.1)

Carbon dioxide releases from raw iron and graphite electrode of the electric arc furnace (EAF) during steel production are reported in 2.C.1.1 Steel subsector. . 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<sub>2</sub>/t steel. The latter was obviously included only in case of electro steel production. Emissions were calculated using the following formula:

$$\text{CO}_2 (\text{Gg}) = \left[ \left( \text{Steel produced (kt)} \times \frac{\text{carbon content, iron (\%)} - \text{carbon content, steel (\%)}}{100} \times \frac{44}{12} \right) + \text{electro steel (kt)} \times 0.005 \right]$$

Carbon content of the pig iron is originating on one hand from the coke and on the other hand from the original carbon content of the iron ore. Pig iron as the input material for BOF (basic oxygen furnace) steel production has a carbon content of 4%, of which 0,5% is remaining in the steel. So, the CO<sub>2</sub> emission calculated from the reduction from 4% to 0,5% = 3,5 % is reported in 2.C.1.1 (steel).

In order to avoid double counting the emissions calculated this way should be subtracted from subsector 2.C.1.4. (Coke consumption). Instead of the total 4% (as 0,5% remaining in the steel is also not emitted into the atmosphere) still the 3,5% is subtracted in order to compensate the original carbon content of the iron ore, which is 0,5% in average and not reported elsewhere. (Of course the original carbon content of the ore is usually eliminated during sintering but it is reported here together for simplification.)

In the case of EAF steel production the input material is usually scrap iron and other unknown material. These feedstock do contain carbon but it is not originating directly from the use of coke of the blast furnace of the given year. So, EAF steel production is included in „Steel produced (kt)” data of the formula above, but the carbon content reduction of EAF steel production is not subtracted from 2.C.1.4.

Quicklime used in BOF furnaces is not produced on-site, as it is declared by the operator.

#### 4.5.1.4 Pig Iron ( CRF sector 2.C.1.2.)

Emission from the use of natural gas in the blast furnace (as reducing agent or other non-energy use) is reported in 2.C.1.2. starting from 2004. Before 2004 emissions of the use of Natural gas (in blast furnaces and for combustion purposes too) are included together in 1.A.2.a.

Consumption of coke in the blast furnace, as the main emission source during pig iron production has a separate subcategory, namely 2.C.1.4. Emission from the „flux” (limestone and dolomite additives) in the blast furnace are reported in 2.A.3.- Limestone and dolomite use subcategory.

#### 4.5.1.5 Coke consumption (CRF sector 2.C.1.4.)

Emission from the use of coke in the blast furnace is reported in this subsector, and the subtracted amount is explained in chapter Steel (2.C.1.1) above.

Please note that the reason for the unstable IEF is on one hand that activity data given in CRF is ton, since it is not possible to change the set up unit of measure of CRF software to joule. But in fact HU uses the activity data of TJ consumption of coke in Blast furnace within Transformation sector from IEA statistics as it is explained in paragraph on Emission factors above. On the other hand the coke remaining in pig iron used in BOF steel production process is reported in 2.C.1.1. subsector and subtracted from here in order to avoid double counting as it is explained in 2.C.1.1 paragraph above. The subtracted amount is not directly correlates with the consumption of coke in the blast furnace, so it will result a changing IEF.

		1985	BY	1986	1987	1988	1989	1990
<b>Consumption of coke in blast furnace</b>	kt	1449	1368,5	1406	1250	1238	1086	1040
<b>Consumption of coke in blast furnace</b>	TJ	39678	37966	38918	35301	34752	30353	28220
<b>CO2 emission in 2.C.1.4</b>	Gg	3 796	3 613	3 709	3 335	3 278	2 839	2 657
<b>CH4 emission in 2.C.1.4</b>	Gg	0,3968	0,3797	0,3892	0,3530	0,3475	0,3035	0,2822
		1991	1992	1993	1994	1995	1996	1997
<b>Consumption of coke in blast furnace</b>	kt	737	656	778	891	870	815	562
<b>Consumption of coke in blast furnace</b>	TJ	19 998	17 801	21 137	24 207	23 636	22 142	16 337
<b>CO2 emission in 2.C.1.4</b>	Gg	1 887	1 697	2 028	2 327	2 281	2 119	1 556
<b>CH4 emission in 2.C.1.4</b>	Gg	0,2000	0,1780	0,2114	0,2421	0,2364	0,2214	0,1634
		1998	1999	2000	2001	2002	2003	2004
<b>Consumption of coke in blast furnace</b>	kt	597	590	639	566	606	549	570
<b>Consumption of coke in blast furnace</b>	TJ	17 654	17 504	19 022	16 849	18 068	16 211	16 736
<b>CO2 emission in 2.C.1.4</b>	Gg	1 677	1 651	1 806	1 567	1 703	1 508	1 560
<b>CH4 emission in 2.C.1.4</b>	Gg	0,1765	0,1750	0,1902	0,1685	0,1807	0,1621	0,1674
		2005	2006	2007	2008	2009	2010	
<b>Consumption of coke in blast furnace</b>	kt	596	601	620	599	593	686	
<b>Consumption of coke in blast furnace</b>	TJ	17 403	17 723	18 271	17 641	17 571	20 484	
<b>CO2 emission in 2.C.1.4</b>	Gg	1 633	1 667	1 714	1 649	1 695	1 953	
<b>CH4 emission in 2.C.1.4</b>	Gg	0,1740	0,1772	0,1827	0,1764	0,1757	0,2048	

**Table 4.13.** Emissions from consumption of coke in blast furnace

#### 4.5.1.6 Uncertainties 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.

#### 4.5.1.7 Source-specific QA/QC information and verification

There is no sector specific information.

#### 4.5.1.8 Source-specific recalculations

In 2012 the subsector 2.C.1.1 (Steel) has been recalculated and a major reallocation between sector 1.A.2.a and 2.C.1.2 (Pig Iron production) and 2.C.1.4 (Coke consumption) has also been performed. The recalculation of 2.C.1.1 is due to correction of activity data of EAF steel production (emissions from graphite electrode). The reallocation of emissions between energy and industry sectors is due to the recommendation of the review report of the 2011 submission. In paragraph 61. ERT recommends that Hungary allocate the emissions from use of coke as a reducing agent in blast furnaces to the industrial processes sector. Fortunately the consumption of coke in blast furnaces is now reported in the IEA Energy statistics in Hungary, so it is possible now to execute the division. Emission from the use of coke in the blast furnaces is reported in 2.C.1.4 and emissions from the use of natural gas in the blast furnace (as reducing agent or other non-energy use) is reported in 2.C.1.2.. Both CO2 and CH4 emissions are reported using kg /TJ default factors from the energy sector in order to achieve more accurate result by using actual NCV data of the year.

For the detailed tables, comparison, etc. please see chapter 10. Recalculations.

#### **4.5.1.9 Source-specific planned improvements**

Reallocation of Limestone and dolomite use of iron and steel industry from 2.A.3 in order to present all the emissions of this sector together. Investigate the possibility to report blast furnace gas (at the moment NOT reported in Energy sector) in this sector as recovery.

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

#### **4.5.2.1 Source category description**

Emitted gas: CO<sub>2</sub>

Key source: NO

Upon smelting alloying additive and iron, together with slag-forming additives, a reduction reaction occurs which results in release of CO<sub>2</sub>.

#### **4.5.2.2 Methodological issues**

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

#### **4.5.2.3 Uncertainties 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.

#### **4.5.2.4 Source-specific QA/QC information and verification**

No sector-specific information is available.

#### **4.5.2.5 Source-specific recalculations**

There was no recalculation.

#### **4.5.2.6 Source-specific planned improvements**

None.

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

#### **4.5.3.1 Source category description**

Emitted gases: CO<sub>2</sub>, PFCs (CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>)

Key source: NO

During alumina electrolysis, CO<sub>2</sub> 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.

#### **4.5.3.2 Methodological issues**

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 4.14. Amount of aluminium produced (t)**

	1985	BY	1986	1987	1988	1989	1990	1991	1992
<b>Aluminium, t</b>	73.86	73.75	73.88	73.50	74.64	75.19	75.16	62.88	26.82
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Aluminium, t</b>	27.88	29.65	31.91	33.47	33.67	33.71	33.64	33.85	34.59
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Aluminium, t</b>	35.29	35.04	34.35	31.78	NO	NO	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<sub>4</sub> 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<sub>2</sub>F<sub>6</sub>. Accordingly, the time series of CF<sub>4</sub> emission is as follows:

**Table 4.15. CF<sub>4</sub> emission in Aluminium Production 2.C.3 sub-sector (1985-2010)**

	1985	BY	1986	1987	1988	1989	1990	1991	1992
<b>CF<sub>4</sub>, Gg</b>	35.87	36.18413	36.29	36.3924	35.5148	38.4233	36.5	31.4986	18.17
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>CF<sub>4</sub>, Gg</b>	19.64	21.4198	22.483	21.4822	21.4139	23.047	23.6	28.4	26.74648
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>CF<sub>4</sub>, Gg</b>	27.18524	25.376	26.9594	28.0105	NO	NO	NO	NO	NO

For each year, emissions were calculated for individual factories and the sum of these is used as annual total. You can find 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 favorable 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<sub>2</sub> was calculated using the default factor (1.8 t/t) and the known production data.

#### 4.5.3.3 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 favorable 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.

#### 4.5.3.4 Source-specific QA/QC information and verification

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.

#### 4.5.3.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.5.3.6 Source-specific 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<sub>6</sub> (CRF sector 2.E)

Halocarbons and SF<sub>6</sub> are not produced in Hungary.

### 4.8 Consumption of Halocarbons and SF<sub>6</sub> (CRF sector 2.F)

Emitted gases: HFCs, PFCs, SF<sub>6</sub>

Key source: Level and Trend for HFCs and Trend for SF<sub>6</sub>

#### 4.8.1 Source category description

This category includes the following emission sources: Refrigeration and Air Conditioning Equipment (2.F.1), Foam Blowing (2.F.2), Fire Extinguishers (2.F.3), Aerosols/Metered Dose Inhalers (2.F.4), Solvents (2.F.5) (solely for years 1998-2002), Electrical Equipment (2.F.8) and Other (2.F.9)

HFCs (partially fluorinated hydrocarbons) are used in household and commercial cooling equipments (2.F.1.), during production of foams used in construction/insulation industry (2.F.2.), in fire extinguishers (2.F.3), in medical and technical sprays (as propellant gas) (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<sub>6</sub> 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<sub>6</sub> is not used as a cover gas in colored metal foundries.

The year 1995 was chosen as base year for HFC, PFC and SF<sub>6</sub> emissions.

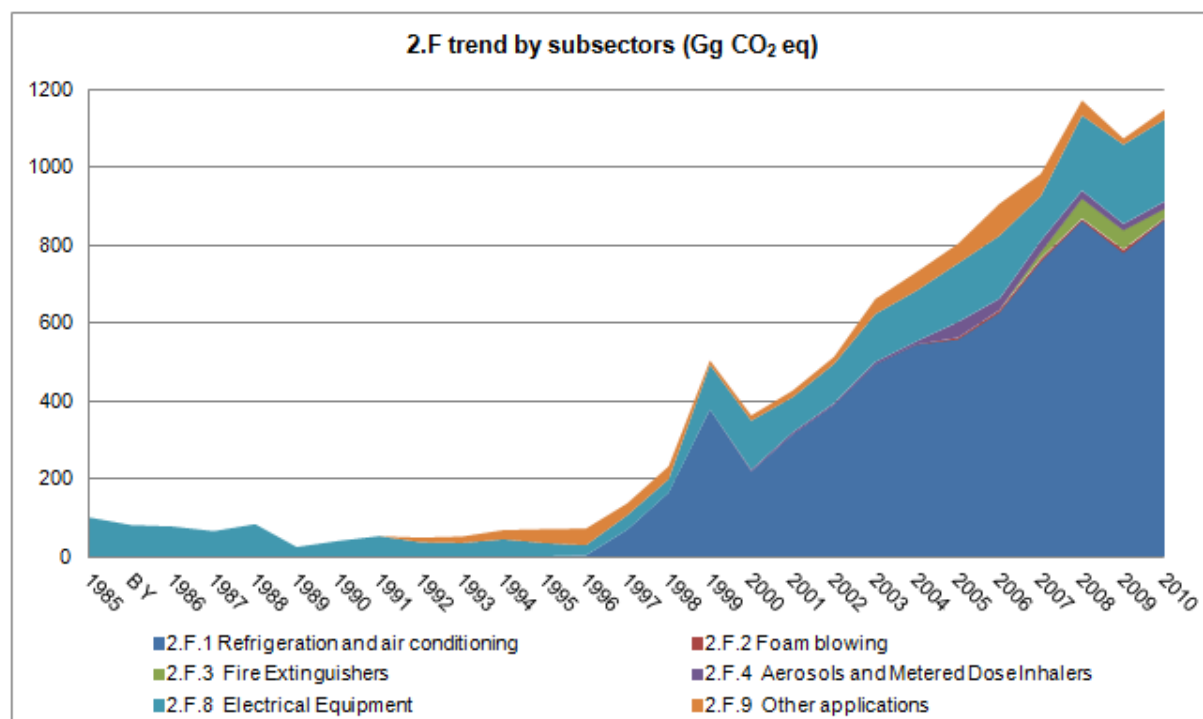
#### 4.8.2 Emission trend

Total emissions estimated from 2.F Consumption of Halocarbons and SF<sub>6</sub> were 1,145.03 Gg CO<sub>2</sub>-eq in 2010, or 26.6% of the total industrial processes emissions compared to 0.7% in 1985-87 and 3.1% in 1995. Total sectoral emissions increased by 572.2% between 1995 and 2010, and increased by 6.7% between 2009 and 2010. This was mainly due to strongly



increasing emissions from the use of HFCs as substitutes for ozone depleting substance (ODS Substitutes).

Figure 4.10 shows the trend of F-gases emissions from 2.F Consumption of Halocarbons and SF<sub>6</sub> by sub-categories for the years 1985 to 2010. 2.F.8 Electrical Equipment sub-sector was the most important emitter in the beginning of the inventory period, nowadays the main source of gases is 2.F.1 Refrigeration and Air Conditioning Equipment sub-sector is showing a growing tendency.



**Figure 4.10.** Actual emission of F gases from sub-sector, 1985-2010 (Gg CO<sub>2</sub>-eq)

Table 4.16 and Table 4.17. show the trend of F-gases potential and actual emissions and actual emissions by gases from 2.F Consumption of Halocarbons and SF<sub>6</sub> for the years 1985 to 2010.

**Table 4.16.** Potential and actual emissions in 2.F sub-sector, Gg CO<sub>2</sub>-eq, (1985-2010)

Gg, CO <sub>2</sub> -eq	1985	B Y	1986	1987	1988	1989	1990	1991	1992
<b>HFCs actual</b>	NO	NO	NO	NO	NO	NO	NO	NO	0.1
<b>HFCs potential</b>	NO	NO	NO	NO	NO	NO	NO	NO	5.2
<b>PFCs actual</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
<b>PFCs potential</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
<b>SF<sub>6</sub> actual</b>	88.5	73.1	65.4	65.3	83.7	72.3	87.6	102.5	99.4
<b>SF<sub>6</sub> potential</b>	88.5	73.1	65.4	65.3	83.7	72.3	87.6	102.5	99.4
<b>Total actual</b>	88.5	73.1	65.4	65.3	83.7	72.3	87.6	102.5	99.5
<b>Total potential</b>	88.5	73.1	65.4	65.3	83.7	72.3	87.6	102.5	104.6
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>HFCs actual</b>	0.1	0.5	0.7	3.4	69.3	163.8	378.0	223.1	323.3
<b>HFCs potential</b>	5.2	26.0	36.8	33.3	127.0	242.4	484.4	345.9	460.0
<b>PFCs actual</b>	NO	NO	NO	NO	0.0	21.6	34.5	0.5	0.6



<b>PFCs potential</b>	NO	NO	NO	NO	0.1	28.4	43.1	1.8	1.8
<b>SF6 actual</b>	129.8	149.5	169.6	174.6	211.3	168.2	205.5	195.3	226.0
<b>SF6 potential</b>	129.8	149.5	169.6	174.6	225.0	179.4	193.5	183.3	214.1
<b>Total actual</b>	129.9	150.0	170.3	178.1	280.6	353.5	617.9	418.9	550.0
<b>Total potential</b>	135.0	175.5	206.4	207.9	352.2	450.2	721.0	531.0	675.9
	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
<b>HFCs actual</b>	398.1	500.3	553.7	602.7	662.5	811.2	940.3	855.0	914.3
<b>HFCs potential</b>	587.5	714.2	800.9	846.2	976.5	1 173.7	1 398.7	1 277.8	1 415.7
<b>PFCs actual</b>	0.9	1.3	1.1	1.6	1.6	2.4	2.4	1.7	0.4
<b>PFCs potential</b>	2.5	2.9	2.3	3.0	3.1	4.4	4.5	3.5	1.2
<b>SF6 actual</b>	174.3	179.6	329.6	237.7	185.8	252.7	275.5	220.6	234.9
<b>SF6 potential</b>	184.8	179.6	363.1	237.3	187.3	247.9	265.8	210.7	234.9
<b>Total actual</b>	573.3	681.2	884.4	842.0	849.8	1 066.3	1 218.2	1 077.3	1 149.55
<b>Total potential</b>	774.9	896.7	1 166.3	1 086.5	1 166.9	1 426.0	1 669.0	1 492.1	1 651.8

Table 4.17. Actual emissions by gases in 2.F sub-sector (t), (1985-2010)

(t)	1985	B Y	1986	1987	1988	1989	1990	1991	1992
HFC-23	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-32	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO	0.1
HFC-152a	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-143a	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-227ea	NO	NO	NO	NO	NO	NO	NO	NO	NO
C <sub>3</sub> F <sub>8</sub>	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF <sub>6</sub>	3.7	3.1	2.7	2.7	3.5	3.0	3.7	4.3	4.2
(t)	1993	1994	1995	1996	1997	1998	1999	2000	2001
HFC-23	NO	NO	NO	NO	0.2	0.2	1.0	0.1	0.0
HFC-32	NO	NO	NO	NO	0.0	0.4	4.5	1.5	2.2
HFC-125	NO	NO	NO	0.0	2.9	9.0	21.7	20.1	25.1
HFC-134a	0.1	0.4	0.6	2.5	36.0	77.1	164.1	63.1	115.9
HFC-152a	NO	NO	NO	NO	0.1	0.2	0.2	0.9	0.8
HFC-143a	NO	NO	NO	0.0	3.1	9.3	23.5	21.7	26.4
HFC-227ea	NO	NO	NO	NO	NO	NO	NO	NO	NO
C <sub>3</sub> F <sub>8</sub>	NO	NO	NO	NO	0.0	0.1	0.1	0.1	0.1
SF <sub>6</sub>	5.4	6.3	7.1	7.3	8.8	7.0	8.6	8.2	9.5
(t)	2002	2003	2004	2005	2006	2007	2008	2009	2010
HFC-23	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HFC-32	3.7	8.2	9.4	10.3	15.7	15.5	19.5	15.9	22.0
HFC-125	39.4	46.1	54.7	52.4	65.6	81.0	94.8	85.6	95.7
HFC-134a	97.6	151.4	148.4	202.4	189.1	209.6	255.4	215.5	243.2
HFC-152a	0.9	1.4	0.8	0.6	12.6	16.9	0.5	0.4	0.9
HFC-143a	41.6	44.2	52.4	48.0	57.2	74.2	77.2	72.8	76.5
HFC-227ea	NO	0.0	0.2	0.9	0.9	5.8	12.2	16.3	8.4
C <sub>3</sub> F <sub>8</sub>	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.1
SF <sub>6</sub>	7.3	7.5	13.8	9.9	7.8	10.6	11.5	9.2	9.8

In 2010, the 2.F.1 Refrigeration and Air Conditioning Equipment sub-sector accounted for 75.3% of total F-gases emissions, followed by 2.F.8 Electrical Equipment sub-sector 18.4%, 2.F.9 Other SF<sub>6</sub> sub-sector 2.2%, 2.F.3 Fire Extinguishers sub-sector 2.1%. (see Figure 4.11).

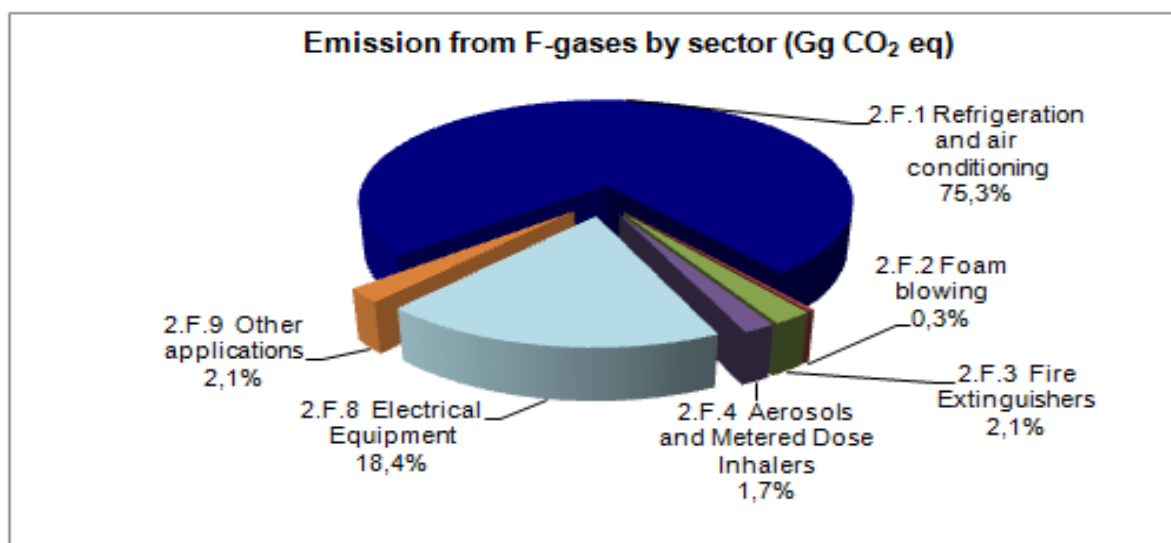


Figure 4.11. Emission from sub-sectors of F gases in 2010, Gg CO<sub>2</sub>-eq

#### 4.8.3 Methodological issues

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 and appear now in Cross-cutting information.

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

Unfortunately, the detailed, company level reporting of F-gases required by the regulation No

842/2006/ EC Regulation is slightly differing from the needs of the inventory, as it does not contain import/export data between Member States and reporting is needed solely above 1 tonne. So, the data reported by the companies received through the competent ministry is useful only for verification and complementary reporting of the companies is still needed.

#### 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 to cover the emission from stocks. Emission estimated based on the default Product Manufacturing Factor is covering emission from manufacturing. 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<sub>6</sub>, 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.

#### 4.8.3.1 2.F.1 Refrigeration and Air Conditioning Equipment

Emitted gases: HFC-125, HFC-32, HFC-143a, HFC-134a, HFC-152a, HFC-23, C<sub>3</sub>F<sub>8</sub>

Emission data, export-import data, refilled amount of domestic and other refrigerators and air-conditioning equipment were received directly from manufacturers of equipments, distributors or trading companies and the minister responsible for the environment from 1992.

Within sector 2.F.1 all the subsectors are reported under 2.F.1.1 Domestic refrigeration and air-conditioning in an aggregated manner. In 2012 submission the CRF Tables were completed for all subsectors using IE notation key and cell comment as it was required by the review report of last year.

In case of all domestic, transport, 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. This is why in CRF tables the Products Life Factor is set to 100%. In fact the activity data included in the column of "Amount of fluid in operating systems" is the refilled quantity reported by the companies. This is regarded as emission entirely, by assuming that refilling is needed in order to replace the amount escaping by leakage. In order to cover emissions from the filling quantity as well, a 1 % default Product Manufacturing factor was included in 2012 submission following the recommendation of the review report of last year.

In the case of manufacturing of domestic refrigerators, 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 alone. Fugitive assembly emissions do not occur when the equipments are filled because the system of filling is a closed system. This information was received from the manufacturer of refrigerators, the only one in Hungary, in an official stamped letter. This is why in this case PMF is not applied.

Table 4.19 show the trend of consumption of F-gases by gases from 2.F.1 Refrigeration and

Air Conditioning Equipment for the years 1985 to 2010.

In subcategory 2F.1. emissions decreased in 2009 and increased again in 2010. The actual emission of HFCs in sector 2.F.1 are in direct correlation with the activity data. The activity data is taken from direct reporting of companies dealing with HFCs within refrigeration industry. Direct reporting consists of data on import, export and refilled (replacing leakage) quantity of HFCs.

Directly reported data is compared with data reported on F-gases required by 842/2006/EC Regulation, but it is evidently not equal. The UNFCCC reporting is wider, since emissions below 1 t and import/export to EU countries and refilled/recovered quantity are also taken into account.

The increase and decrease of the activity data is depending on the economic situation of this sector. The economy in general and the machine industry especially were in recession in year 2009 and a recovery in year 2010 (except for building sector) as it is reflected in volume indices presented in Table 4.18. So, in 2009 the economic situation might not have been favorable for refrigeration industry either affecting the emissions too.

**Table 4.18** Volume index of industrial production in Hungary

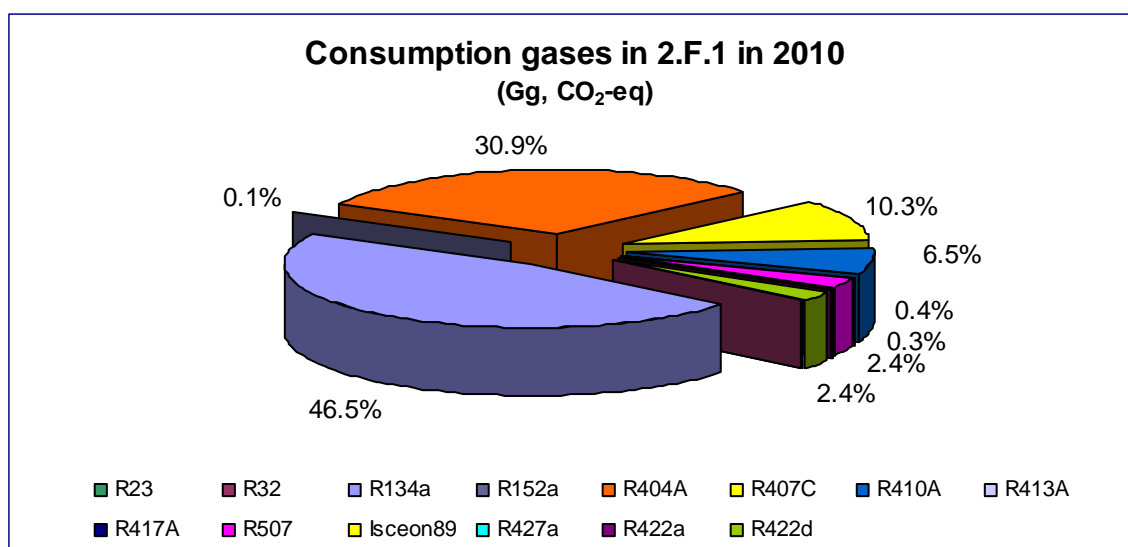
	2005	2006	2007	2008	2009	2010
Volume index of industrial production (% of the data of year before)	106.9	110.2	107.9	99.9	82.1	110.8

**Table 4.19.** Actual emission of F gases in 2.F.1 sub-sector, 1985-2010, (t)

	1996	1997	1998	1999	2000	2001	2002	2003
HFC-23 (t) (GWP: 11700)	NO	0.2	0.2	1.0	0.1	0.0	0.0	0,1
HFC-32 (t) (GWP: 650)	NO	0.0	0.4	4.5	1.5	2.2	3.7	8,2
HFC-125 (t) (GWP: 2800)	0.0	2.9	9.0	21.7	20.1	25.1	39.4	46,1
HFC-134a (t) (GWP: 1300)	2.5	36.0	77.1	163.6	59.5	108.1	90.3	145,6
HFC-152a (t) (GWP: 140)	NO	0.1	0.2	0.2	0.2	0.1	NO	0,6
HFC-143a (t) (GWP: 3800)	0.0	3.1	9.3	23.5	21.7	26.4	41.6	44,2
C <sub>3</sub> F <sub>8</sub> (t) (GWP:7000)	NO	0.007	0.095	0.107	0.077	0.092	0.125	0,189
	2004	2005	2006	2007	2008	2009	2010	
HFC-23 (t) (GWP: 11700)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
HFC-32 (t) (GWP: 650)	9.4	10.3	15.7	15.5	19.5	15.9	22.0	
HFC-125 (t) (GWP: 2800)	54.7	52.4	65.6	80.1	88.1	83.1	95.4	
HFC-134a (t) (GWP: 1300)	141.6	169.5	164.6	184.4	236.5	199.6	226.0	
HFC-152a (t) (GWP: 140)	0.0	0.0	0.0	0.0	0.1	0.1	0.7	
HFC-143a (t) (GWP: 3800)	52.4	48.0	57.2	74.2	77.2	72.8	76.5	
C <sub>3</sub> F <sub>8</sub> (t) (GWP:7000)	0.160	0.224	0.229	0.343	0.347	0.249	0.051	

#### Activity data

For 2010, we received data from 9 distributors of F gases and one manufacture of refrigerators. The distributors provide data on export, import and sold amount of the different gases. Hungary imported 739.1 t F gases in 2010 and exported only 72.2 t within the field of refrigeration and air conditioning, the effective domestic use was 647.3 t. The most used gases are the HFC-134a, R-404A and R407C. (see Figure 4.12)



**Figure 4.12.** Consumption F gases in 2.F.1 sub-sector in 2010, Gg CO<sub>2</sub>-eq

#### Emission factors

The distributors also give information on their users, e.g. what is the main purpose of their use, or whether they're buying these gases for filling in new products or for refill during repair. The users of gases are thus classified: the share of refill varies between 2% and 100% among them with an average value about 70%. It is assumed that the amount of gas used for refill compensates all previous leakages and this very amount is regarded as emission. (In a very simplified way, we can say that 70% of all domestically sold F-gases in this subcategory are assumed to be the emission.). Using this method we think that all significant sources of commercial and industrial refrigeration are included, however, we do not have information whether the refills are made in refrigerators or in air conditioning equipments, or mobile air conditioners in cars therefore all emissions are accounted for in an aggregated manner in this sub-sector. So, in CRF tables the activity data on "Amount of fluid in operating systems" is the refilled quantity, and product life factor (PLF) is set to 100% in order to have all the refilled quantity as emission.

In the review report of last year Hungary was encouraged to use a Product Manufacturing Factor (PMF) and report emissions from manufacture of air-conditioning and refrigeration equipment too. After consideration that in sector 2.F.1.1 all the refrigeration and air-conditioning emissions are reported in an aggregated manner, a PMF value of 1% was added from the default EF range provided in the IPCC1996 Guidebook.

In addition the F-gas regulation of the EU (Regulation (EC) No 842/2006) includes rigorous requirements for the handling, personnel training, etc, aiming to reduce leakage in every phase of the life cycle of the F-gases. As the regulation is directly applicable in all Member States, it is also implemented in Hungary. It seems very probable that this measure also confirm a low product manufacturing factor.

PMF factor is not to apply for the manufacturer of the refrigerators, who declared to have a closed assembly system. So, the amount of F-gases reported by this manufacturer is subtracted from the activity data.

#### 4.8.3.2 2.F.2 Foam Blowing

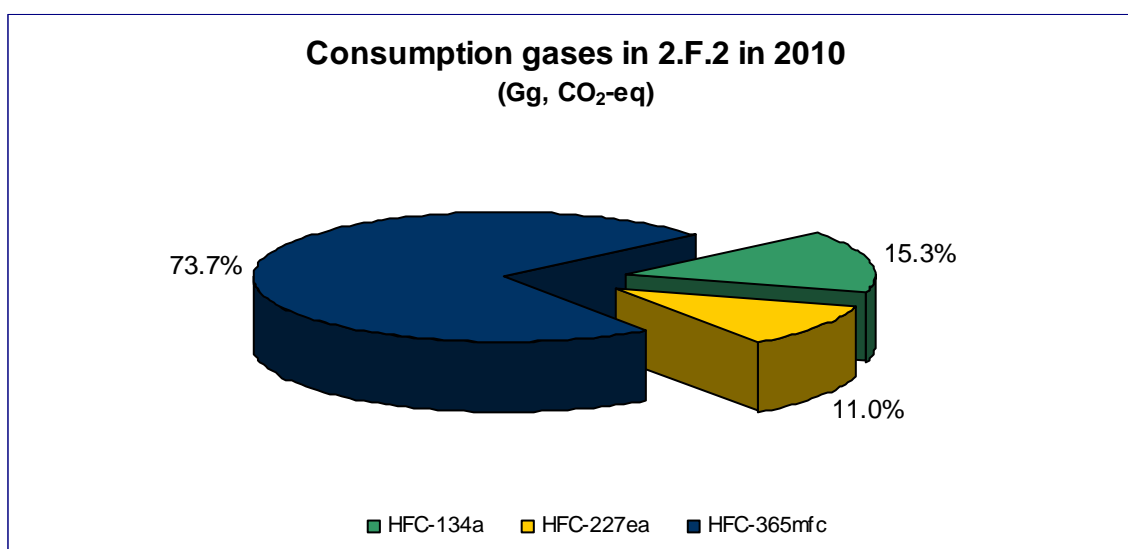
Emitted gases: HFC 134a, HFC-152a, HFC-227ea

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.

#### Activity data

Hungary imported 40.01 t F gases and exported only 2.8 t within the foam production subsector in 2010, the effective domestic use was 37.3 t. The most used gases are the HFC-365mfc (see Cross cutting information), HFC-134a and HFC-227ea. (see *Figure 4.13.*)



**Figure 4.13.** Consumption F gases in 2.F.2 sub-sector in 2010, Gg CO<sub>2</sub>-eq

#### Emission factors

##### 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:

$$\text{Emissions from Open-Cell Foam} = \text{Total Annual HFCs Used in Manufacturing Open-Cell Foam}$$

##### 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:

$$\text{Emissions from Closed-cell Foam} = [(\text{Total HFCs Used in Manufacturing New Closed-cell Foam in year } t) \cdot (\text{first-year Loss Emission Factor})] + [(\text{Original HFC Charge Blown into Closed-cell Foam Manufacturing between year } t \text{ and year } t - n) \cdot (\text{Annual Loss Emission Factor})]$$



The used default assumptions for our calculations are shown in *Table 4.20*.

**Table 4.20.** *Default emission factor for HFCs from Closed-Cell foam*

Default emission factor for HFCs from Closed-Cell foam	
	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<sub>2</sub>-eq emissions are equal to the sum of CO<sub>2</sub>-eq 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.

#### 4.8.3.3 2.F.3 Fire Extinguishers

Emitted gases: HFC 125, HFC-227ea

Activity data, mainly import and export data, were obtained directly from the fire protection companies. Currently, our emission calculations are based on the method of potential emissions (Tier1). To our knowledge, PFCs are not used in fire extinguishing equipments and HFCs are applied only in flooding equipments.

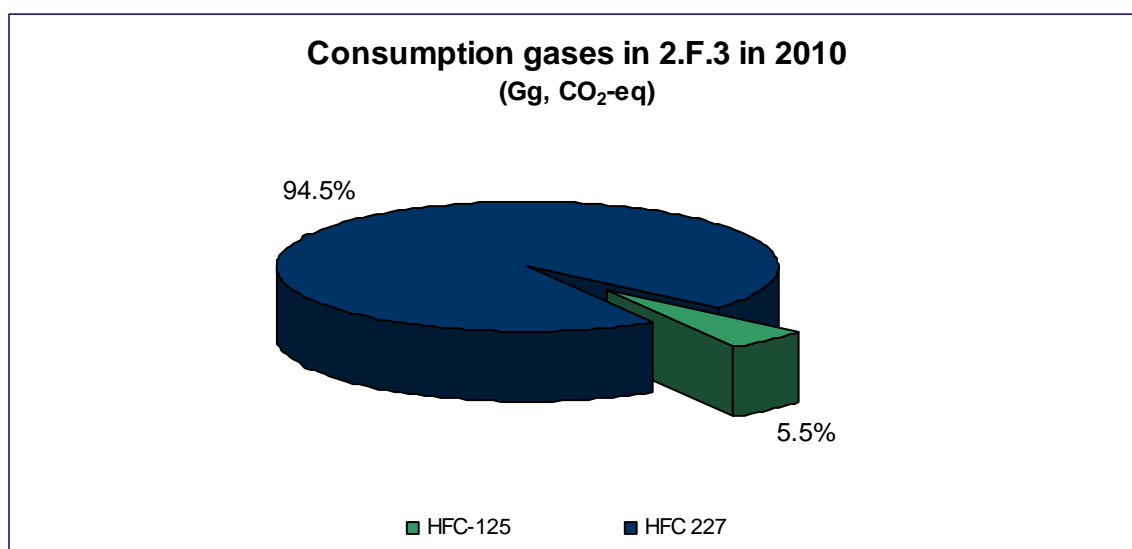
**Table 4.21.** *Actual, potential and consumption of F-gases in 2.F.3 sub-sector (1985-2010)*

	1985	1985-87	1986	1987	1988	1989	1990	1991	1992
Actual emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	NO	NO	NO	NO	NO	NO
Potential emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125, t	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-227ea, t	NO	NO	NO	NO	NO	NO	NO	NO	NO
	1993	1994	BY	1996	1997	1998	1999	2000	2001
Actual emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	NO	NO	NO	NO	NO	NO
Potential emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-125, t	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFC-227ea, t	NO	NO	NO	NO	NO	NO	NO	NO	NO
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Actual emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	0.1	0.6	17.3	51.9	49.4	24.6
Potential emissions, Gg CO <sub>2</sub> eq	NO	NO	NO	0.1	0.6	17.3	51.9	49.8	37.7
HFC-125, t	NO	NO	NO	NO	NO	0.9	6.7	2.5	0.4
HFC-227ea, t	NO	NO	NO	0.0	0.2	5.0	11.4	14.6	8.1

#### Activity data

Hungary imported 13.03 t F gases in 2010 and there was no export within the field of fire extinguishers, the effective domestic use was 13.03 t. The most used gases are the HFC-227ea and HFC-125. (see Figure 4.14)





**Figure 4.14.** Consumption F gases in 2.F.3 sub-sector in 2010, Gg CO<sub>2</sub>-eq

#### Emission factors

As regards fire extinguishers, emission data were received directly from the installing firms. It is assumed that the quantities previously released into the atmosphere are replenished and these amounts are taken as the emissions.

#### 4.8.3.4 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. Data were received directly from the producers or distributors.

**Table 4.22.** Actual, potential and consumption of F-gases in 2.F.3 sub-sector (1985-2010)

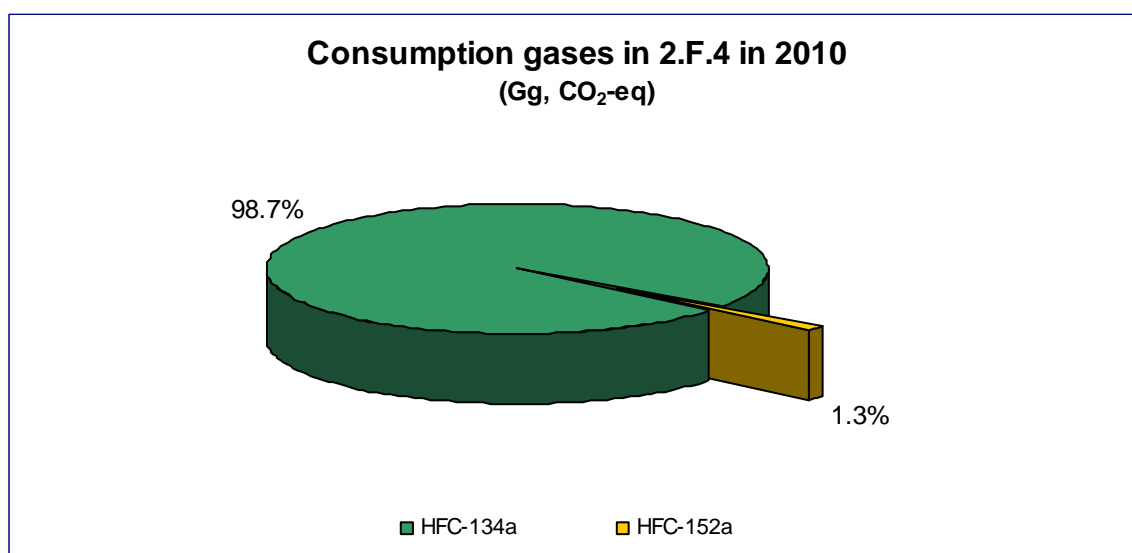
	1985	B Y	1986	1987	1988	1989	1990	1991	1992
<b>Actual emissions, Gg CO<sub>2</sub>eq</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
<b>Potential emissions, Gg CO<sub>2</sub>eq</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
<b>HFC-124a, t</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
<b>HFC-152a, t</b>	NO	NO	NO	NO	NO	NO	NO	NO	NO
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Actual emissions, Gg CO<sub>2</sub>eq</b>	NO	NO	NO	NO	NO	NO	0.6	4.8	6.4
<b>Potential emissions, Gg CO<sub>2</sub>eq</b>	NO	NO	NO	NO	NO	NO	0.6	4.8	6.4
<b>HFC-124a, t</b>	NO	NO	NO	NO	NO	NO	0.4	3.6	4.9
<b>HFC-152a, t</b>	NO	NO	NO	NO	NO	NO	NO	0.7	0.8

	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Actual emissions, Gg CO<sub>2</sub>eq</b>	5.6	7.4	8.2	40.3	29.4	30.1	21.6	17.2	19.6
<b>Potential emissions, Gg CO<sub>2</sub>eq</b>	5.6	7.4	8.2	40.3	29.4	30.1	21.6	17.2	19.6
<b>HFC-124a, t</b>	4.2	5.6	6.2	30.9	22.6	23.1	16.5	13.2	15.0
<b>HFC-152a, t</b>	0.9	0.8	0.7	0.6	0.4	0.5	0.4	0.3	0.2

#### Activity data

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.

Hungary imported 106.4 t F gases and exported 91.1 t within the field of aerosol/MDI production in 2010, the effective domestic use was 15.2 t. The most used gases are the HFC-134a and HFC-152a. (see Figure 4.15)



**Figure 4.15.** Consumption F gases in 2.F.4 sub-sector in 2010, Gg CO<sub>2</sub>-eq

#### Emission factors

Aerosol emissions are considered prompt because all the initial charge escape within the first year after sale. Therefore, to estimate emissions it is necessary to know the total amount of aerosol initially charged in product. This method is applied to each chemical individually.

#### 4.8.3.5 2.F.8 Electrical Equipment

SF<sub>6</sub> 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.

#### Activity data

Hungary imported 18.776 t SF<sub>6</sub> gas and exported 9.979 t within the field of electrical equipment in 2010, the effective domestic use was 8.798 t. For 2010, we received data from

6 manufacturers. One of the manufacturers using SF<sub>6</sub> representing around 10% of domestic SF<sub>6</sub> use did not report for the years between 2006 and 2008. Activity data were extrapolated from the previous two years. Thanks to our government decree, we could collect the missing data eventually, so we recalculated the emissions. This recalculation resulted in an increase of emissions, as shown in *Table 4.23*.

**Table 4.23. Actual and potential emissions in 2.F.8 sub-sector (1985-2010)**

	1985	B Y	1986	1987	1988	1989	1990	1991	1992
<b>Actual emissions, t</b>	3.703	3.057	2.736	2.731	3.500	3.026	3.666	4.289	3.660
<b>Potential emissions, t</b>	3.703	3.057	2.736	2.731	3.500	3.026	3.666	4.289	3.660
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>Actual emissions, t</b>	4.733	5.255	5.596	5.507	6.251	4.216	7.608	7.090	8.247
<b>Potential emissions, t</b>	4.733	5.255	5.596	5.507	6.825	4.687	7.608	7.090	8.247
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Actual emissions, t</b>	6.022	5.873	11.782	7.767	4.208	8.192	9.900	8.569	8.798
<b>Potential emissions, t</b>	6.962	5.873	13.182	7.748	4.271	7.990	9.492	8.156	8.798

#### Emission factors

Emission data were received directly from the manufacturers. It is assumed that the quantities previously released into the atmosphere are replenished and these amounts are taken as the emissions.

#### 4.8.3.6 2.F.9 Other applications

In subcategory 2.F.9. the emissions increased after the continuous decrease since 2006. The actual emission of SF<sub>6</sub> in sector 2.F.9 is in direct correlation with the activity data. The activity data is taken from direct reporting of all companies dealing with SF<sub>6</sub> except for the uses during electricity generation and distribution and switchgear production (latter are reported in 2.F.8). The activities reported in 2.F.9 are: sound-proof window production, scientific research and other non defined purposes.

Direct reporting of the companies consists of data on import and export quantity of SF<sub>6</sub>.

This data is compared with data reported on F-gases required by 842/2006/EC Regulation, but it is evidently not equal. The UNFCCC reporting is wider, since emissions below 1 t and import/export to EU countries are also taken into account.

In 2.F.9 the emissions are the potential emissions, since TIER1 method is applied, where Emission=Total import-total export.

The increase and decrease of the activity data is depending on export-import activities of the sector reflecting the economic situation. The economy in general and the machine industry especially were in recession in year 2009 and a recovery in year 2010 (except for the building industry) as it is reflected in volume indices presented in Table 4.18. So, in 2009 the economic situation might not have been favorable for this industrial sector either, affecting the emissions too. In 2010 two companies reported more than 50% higher data than in 2009. Both were checked and the increase can be explained by growth of production.

#### Activity data

SF<sub>6</sub> is used in a variety of additional applications including its usage as an insulating medium in sound proof windows, for leak testing, for researches or experiments. Information of traded

gases were obtained from distributors. 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.

#### Emission factors

The calculation formula is based on the basic method (Tier1)

$$\text{Potential emission} = \text{Import-Export}$$

The following table shows the actual and potential emissions from 2.F.9 sub-sector:

**Table 4.24. Actual and potential emissions in 2.F.9 sub-sector (1985-2010)**

	1985	B Y	1986	1987	1988	1989	1990	1991	1992
Actual emissions, t	NO	NO	NO	NO	NO	NO	NO	NO	0.500
Potential emissions, t	NO	NO	NO	NO	NO	NO	NO	NO	0.500
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Actual emissions, t	0.700	1.000	1.500	1.800	2.590	2.820	0.990	1.080	1.210
Potential emissions, t	0.700	1.000	1.500	1.800	2.590	2.820	0.990	1.080	1.210
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Actual emissions, t	1.270	1.640	2.010	2.180	3.565	2.382	1.628	0.659	1.032
Potential emissions, t	1.270	1.640	2.010	2.180	3.565	2.382	1.628	0.659	1.032

#### 4.8.3.7 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.

#### 4.8.4 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<sub>6</sub> emission may be considered favorable 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.

#### 4.8.5 Source-specific QA/QC information and verification

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.

#### 4.8.6 Source-specific recalculations

In 2012 submission subsector 2.F.1.1 was recalculated due to the inclusion of Product Manufacturing Factor (PMF). For details, please see chapter 4.8.3.1.

**Table 4.25. Actual and potential emissions in 2.F.1.1 sub-sector**

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
HFC actual emission 2011 submission (Gg CO <sub>2</sub> eq)	0.10	0.10	0.52	0.74	3.37	68.92	163.14	376.51	217.19	311.71
HFC actual emission 2012 submission (Gg CO <sub>2</sub> eq)	0.10	0.10	0.52	0.74	3.44	69.29	163.76	377.42	218.27	312.93
Difference (Gg CO <sub>2</sub> eq)	0.00	0.00	0.00	0.00	0.07	0.37	0.62	0.91	1.08	1.22
Difference %	0.00%	0.00%	0.00%	0.00%	2.01%	0.53%	0.38%	0.24%	0.50%	0.39%
	2002	2003	2004	2005	2006	2007	2008	2009	2010	
HFC actual emission 2011 submission (Gg CO <sub>2</sub> eq)	386.81	490.69	541.81	554.82	623.25	752.96	857.49	776.12	n.a.	
HFC actual emission 2012 submission (Gg CO <sub>2</sub> eq)	388.59	492.64	544.21	557.17	626.22	756.57	861.70	779.81	866.33	
Difference (Gg CO <sub>2</sub> eq)	1.78	1.96	2.39	2.35	2.97	3.61	4.21	3.69	n.a.	
Difference %	0.46%	0.40%	0.44%	0.42%	0.48%	0.48%	0.49%	0.48%	n.a.	

	1995	1996	1997	1998	1999	2000	2001	2002
PFC actual emission 2011 submission (Gg CO <sub>2</sub> eq)	NO	NO	0.04	0.65	0.73	0.53	0.64	0.86
PFC actual emission 2012 submission (Gg CO <sub>2</sub> eq)	NO	NO	0.05	0.66	0.75	0.54	0.65	0.88
Difference (Gg CO <sub>2</sub> eq)	NO	NO	0.00	0.01	0.02	0.01	0.01	0.02
Difference %	NO	NO	2.33%	2.16%	2.33%	2.33%	1.89%	1.95%
	2003	2004	2005	2006	2007	2008	2009	2010
PFC actual emission 2011 submission (Gg CO <sub>2</sub> eq)	1.31	1.11	1.55	1.59	2.38	2.41	1.72	n.a.
PFC actual emission 2012 submission (Gg CO <sub>2</sub> eq)	1.32	1.12	1.57	1.60	2.40	2.43	1.74	0.36
Difference (Gg CO <sub>2</sub> eq)	0.02	0.01	0.01	0.02	0.02	0.02	0.02	n.a.
Difference %	1.25%	1.09%	0.92%	0.95%	0.87%	0.88%	1.04%	n.a.

In addition, a comprehensive checking was carried out in 2.F.8 and 2.F.9 sub-sector in this year. All activity data has been verified and all calculations from the year 1985 has been updated. The calculation and copying errors were corrected. Besides, new data were added to 2.F.8 sub-sector: One of the manufacturers using SF<sub>6</sub>, representing around 10% of SF<sub>6</sub> use, did not report for the years between 2006 and 2008. Activity data were extrapolated from the previous 2 years. Thanks to our government decree, we could collect the missing data eventually, so we recalculated the emissions.

These recalculations resulted in an increase of emissions, as shown in *Table 4.26.*, *Table 4.27.*, *Table 4.28.*, *Table 4.29.* and *Table 4.30.*

**Table 4.26. Changes in 2.F.8 sub-sector in actual emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	4.203	3.390	3.236	2.731	3.500	1.028	1.668
Submission 2012 (t)	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference, (t )	-0.50	-0.33	-0.50	0.00	0.00	2.00	2.00
Percentage change	-11.90%	-9.83%	-15.45%	0.00%	0.00%	194.36%	119.78%

	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	2.206	1.549	1.467	1.843	1.435	1.087	1.551
Submission 2012 (t )	4.289	3.660	4.733	5.255	5.596	5.507	6.251
Difference, (t )	2.083	2.111	3.266	3.412	4.161	4.420	4.700
Percentage change	94.4%	136.2%	222.6%	185.1%	290.0%	406.6%	303.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	1.455	4.816	5.282	3.785	4.232	5.135	5.445
Submission 2012 (t )	4.216	7.608	7.090	8.247	6.022	5.873	11.782
Difference, (t )	2.761	2.792	1.808	4.462	1.790	0.738	6.337
Percentage change	189.8%	58.0%	34.2%	117.9%	42.3%	14.4%	116.4%
	2005	2006	2007	2008	2009		
Submission 2011 (t )	6.303	6.767	4.800	8.075	8.532		
Submission 2012 (t )	7.767	4.208	8.192	9.900	8.569		
Difference, (t )	1.464	-2.559	3.392	1.825	0.037		
Percentage change	23.2%	-37.8%	70.7%	22.6%	0.4%		

**Table 4.27. Changes in 2.F.8 sub-sector in potential emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (Gg)	0.00420	0.00339	0.00324	0.00273	0.00350	0.00326	0.00367
Submission 2012 (Gg)	0.00370	0.00306	0.00274	0.00273	0.00350	0.00303	0.00367
Difference (Gg)	-0.00050	-0.00033	-0.00050	0.00000	0.00000	-0.00023	0.00000
Percentage change	-11.9%	-9.8%	-15.5%	0.0%	0.0%	-7.2%	0.0%
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (Gg)	0.00420	0.00355	0.00446	0.00484	0.00543	0.00508	0.00555
Submission 2012 (Gg)	0.00429	0.00366	0.00473	0.00526	0.00560	0.00551	0.00682
Difference (Gg)	0.00008	0.00011	0.00027	0.00042	0.00017	0.00042	0.00128
Percentage change	2.0%	3.2%	6.0%	8.6%	3.0%	8.3%	23.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (Gg)	0.00409	0.00729	0.00633	0.00793	0.00644	0.00557	0.00926
Submission 2012 (Gg)	0.00469	0.00761	0.00709	0.00825	0.00696	0.00587	0.01318
Difference (Gg)	0.00060	0.00031	0.00076	0.00032	0.00052	0.00031	0.00392
Percentage change	14.6%	4.3%	12.0%	4.0%	8.1%	5.5%	42.4%
	2005	2006	2007	2008	2009		
Submission 2011 (Gg)	0.00775	0.00394	0.00623	0.01069	0.00812		
Submission 2012 (Gg)	0.00775	0.00427	0.00799	0.00949	0.00816		
Difference (Gg)	0.00000	0.00033	0.00176	-0.00120	0.00004		
Percentage change	0.0%	8.3%	28.3%	-11.2%	0.5%		

**Table 4.28.** *Changes in 2.F.9 sub-sector in actual=potential emission (1985-2009)*

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	NO	NO	NO	NO	NO	NO	NO
Submission 2012 (t )	NO	NO	NO	NO	NO	NO	NO
Difference, (t )	-	-	-	-	-	-	-
Percentage change	-	-	-	-	-	-	-
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	NO	0.50000	0.70000	1.00000	1.50000	1.80000	1.29500
Submission 2012 (t )	NO	0.50000	0.70000	1.00000	1.50000	1.80000	2.59000
Difference, (t )	-	0.000	0.000	0.000	0.000	0.000	1.295
Percentage change	-	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	1.41000	0.49000	0.58000	0.71000	0.77000	1.64000	2.01000
Submission 2012 (t )	2.82000	0.99000	1.08000	1.21000	1.27000	1.64000	2.01000
Difference, (t )	1.410	0.500	0.500	0.500	0.500	0.000	0.000
Percentage change	100.0%	102.0%	86.2%	70.4%	64.9%	0.0%	0.0%
	2005	2006	2007	2008	2009		
Submission 2011 (t )	2.10800	3.46100	2.38200	1.62790	0.65880		
Submission 2012 (t )	2.18000	3.56500	2.38240	1.62790	0.65880		
Difference, (t )	0.072	0.104	0.000	0.000	0.000		
Percentage change	3.4%	3.0%	0.0%	0.0%	0.0%		

**Table 4.29.** *Changes in 2.F.8-9 sub-sector in actual emission (1985-2009)*

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	4.203	3.390	3.236	2.731	3.500	1.028	1.668
Submission 2012 (t )	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference, (t )	-0.500	-0.333	-0.500	0.000	0.000	1.998	1.998
Percentage change	-0.12	-0.10	-0.15	0.00	0.00	1.94	1.20
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	2.206	2.049	2.167	2.843	2.935	2.887	2.846
Submission 2012 (t )	4.289	4.160	5.433	6.255	7.096	7.307	8.841
Difference, (t )	2.083	2.111	3.266	3.412	4.161	4.420	5.995
Percentage change	0.94	1.03	1.51	1.20	1.42	1.53	2.11
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	2.865	5.306	5.862	4.495	5.002	6.775	7.455
Submission 2012 (t )	7.036	8.598	8.170	9.457	7.292	7.513	13.792
Difference, (t )	4.171	3.292	2.308	4.962	2.290	0.738	6.337
Percentage change	1.46	0.62	0.39	1.10	0.46	0.11	0.85



	2005	2006	2007	2008	2009
Submission 2011 (t )	8.411	10.228	7.182	9.702	9.191
Submission 2012 (t )	9.947	7.773	10.574	11.527	9.228
Difference, (t )	1.536	-2.455	3.392	1.825	0.037
Percentage change	0.18	-0.24	0.47	0.19	0.00

**Table 4.30.** *Changes in 2.F.8-9 sub-sector in potential emission (1985-2009)*

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t)	4.203	3.390	3.236	2.730	3.506	3.026	3.666
Submission 2012 (t)	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference (t)	-0.500	-0.333	-0.500	0.001	-0.006	0.000	0.000
Percentage change	-0.12	-0.10	-0.15	0.00	0.00	0.00	0.00
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t)	4.204	4.047	5.164	5.840	6.931	6.883	8.137
Submission 2012 (t)	4.289	4.160	5.433	6.255	7.096	7.307	9.415
Difference (t)	0.085	0.113	0.269	0.415	0.165	0.424	1.278
Percentage change	0.02	0.03	0.05	0.07	0.02	0.06	0.16
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t)	6.910	7.784	7.308	8.241	7.211	7.207	13.468
Submission 2012 (t)	7.507	8.098	7.670	8.957	7.732	7.513	15.192
Difference (t)	0.597	0.314	0.362	0.716	0.521	0.306	1.724
Percentage change	0.09	0.04	0.05	0.09	0.07	0.04	0.13
	2005	2006	2007	2008	2009		
Submission 2011 (t)	9.928	8.566	11.218	12.570	9.997		
Submission 2012 (t)	9.928	7.836	10.372	11.120	8.815		
Difference (t)	0.000	-0.731	-0.846	-1.451	-1.181		
Percentage change	0.00	-0.09	-0.08	-0.12	-0.12		

#### 4.8.7 Source-specific 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)

#### 4.9.1 Source category description

Emitted gases: CO<sub>2</sub>

Key source: Level and Trend: Feedstocks, CO<sub>2</sub>

#### 4.9.2 Methodological issues

This category was created for calculating carbon dioxide emissions from fuels used as feedstock or other non-energy purposes. CO<sub>2</sub> emissions arise from oxidization during use. Methane emissions are expected to be minor or not to occur at all.

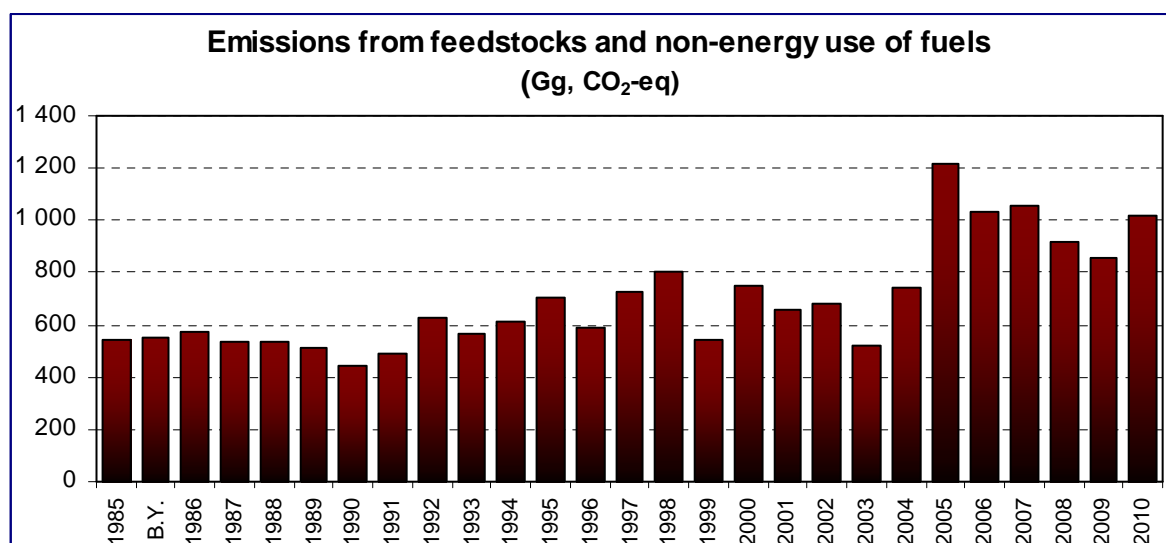


Figure 4.16. Emission from feedstock and non-energy use of fuels Gg, CO2-eq

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<sub>2</sub> 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 productions not reported here. However there are some examples, where only non-CO<sub>2</sub> emissions originating from feedstock (e.g. CH<sub>4</sub> from ethylene and carbon black manufacturing or NMVOC from other refinery products manufacturing) are to be reported in the relevant industrial processes sub-sectors. In this cases CO<sub>2</sub> emissions, if relevant, are still reported in sector 2.G. in an aggregated manner.

In this year it was noted that there are some discrepancies between the amount (TJ) of natural gas as a feedstock reported in the Hungarian Energy Statistics and the sum of natural gas used in the Industrial Processes subsector. The difference was corrected for years 2009 and 2010. Further investigation and completion of the whole time series is planned.

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.

#### 4.9.3 Source category description recalculations

In 2012 submission activity data of year 2009 was recalculated due to the review of amount of natural gas feedstock not included in other industrial processes subsectors. For comparison and the detailed data please see chapter 10 Recalculation.

#### 4.9.4 Source-specific planned improvements

This category contains a number of unknown consumers of these fuels. In order to avoid double counting, further analysis is needed, especially in the case of natural gas for the

whole time series. A thorough review of the allocation of natural gas used for energy and non-energy purposes and as a feedstock is needed in order to perform the reallocations recommended by the review of last year (especially in the case of hydrogen production).

## 4.10 References

Intergovernmental Panel on Climate Change (IPCC), 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, Organisation for Economic Cooperation and Development, and International Energy Agency. (IPCC/OECD/IEA), UK Meteorological Office, Bracknell.

Available online at: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>

Intergovernmental Panel on Climate Change (IPCC), 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change National Greenhouse Gas Inventories Programme, Institute for Global Environmental Strategies, Japan.

Available online at: <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

Hungarian Central Statistical Office (HCSO), 2010: Statistical yearbook of Hungary (In Hungarian: Magyar statisztikai évkönyv, 2010), Budapest.

European Asphalt Pavement Association, Asphalt in Figure 2010, [http://www.eapa.org/usr\\_img/Asphalt%20in%20figures%20Version%2022-12-2011.pdf](http://www.eapa.org/usr_img/Asphalt%20in%20figures%20Version%2022-12-2011.pdf)

World Steel Association - [www.worldsteel.org](http://www.worldsteel.org)

European Steel Association - [www.eurofer.org](http://www.eurofer.org)

Energy Centre: Energy Statistics Yearbook, 2010 (In Hungarian: Energiagazdálkodási Statisztikai Évkönyv, 2010), Budapest.

[http://www.uhde.eu/fileadmin/documents/brochures/uhde\\_brochures\\_pdf\\_en\\_5000028.pdf](http://www.uhde.eu/fileadmin/documents/brochures/uhde_brochures_pdf_en_5000028.pdf)

EnviNOx-Setting Emission Standard for Nitric Acid Plants

<http://ji.unfccc.int/JIITLProject/DB/GSZRV07J6MCQRD8BAZ3MN839PHNZE5/details>

[http://klima.kvvm.hu/documents/116/Nitrog\\_nm\\_vekZrt\\_\\_ves\\_jelent\\_s2008publikus.pdf](http://klima.kvvm.hu/documents/116/Nitrog_nm_vekZrt__ves_jelent_s2008publikus.pdf)

589/2007/EC EU ETS Monitoring and Reporting Guidelines

2008/1/EC Directive on Integrated Pollution Prevention and control

European Commission, 2001. Integrated Pollution Prevention and Control (IPPC), Best Available Techniques Reference Documents. BAT-BREF –s : <http://eippcb.jrc.es/reference/>

EMEP/EEA 2009 – Air Pollutant Emission Inventory Guidebook

Regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register) <http://prtr.ec.europa.eu/>

842/2006/ EC Regulation on certain fluorinated greenhouse gases

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

### 5.1 Overview of the sector

#### 5.1.1 Source category description

Emitted gases: N<sub>2</sub>O, CO<sub>2</sub>, NMVOC

Key sources: Level and Trend, Other (3.D), N<sub>2</sub>O

#### 5.1.2 Methodological issues

Primarily, emissions from paint and solvent uses were calculated in this sector. In addition, technologies related to use of N<sub>2</sub>O are included. The figure below shows the time series of the emissions from the sector:

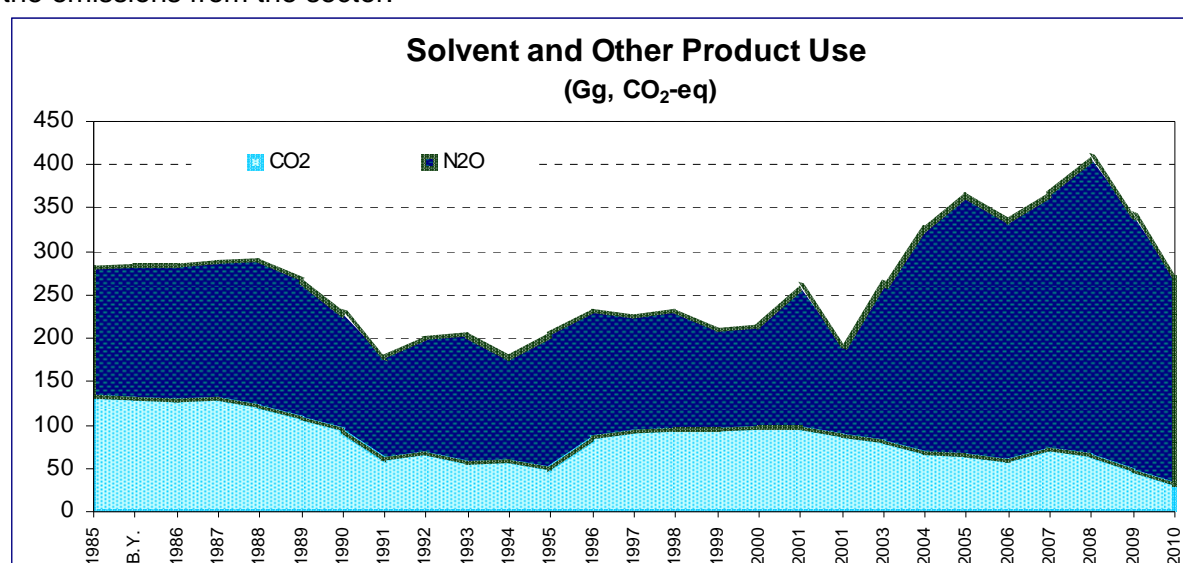


Figure 5.1. CO<sub>2</sub> and N<sub>2</sub>O emissions in Solvent and Other Product Use sector (1985-2010)

In 2010 this category had a contribution of 0.5% (excluding LULUCF) to total greenhouse gas emissions (268.88 Gg CO<sub>2</sub> equivalents). There has been an decrease of 5.5% from base year to 2010 and decrease of 20.9% between 2009 and 2010.

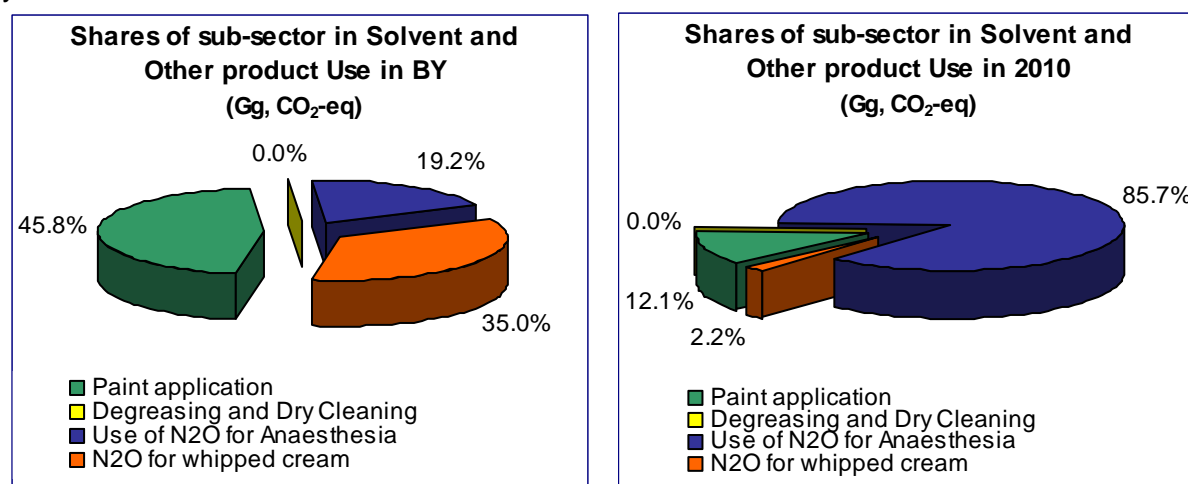


Figure 5.2. Shares of sub-sectors in Solvent sector, in base year and 2010 (Gg CO<sub>2</sub>-eq)

In the base year, the paint application sub-sector accounted for 45.8% of total GHG emissions from solvents, followed by emission from whipped cream sub-sector 35.0%, use of

N<sub>2</sub>O for anaesthesia sub-sector 19.2% and degreasing and dry cleaning 0.04%. In 2010, use of N<sub>2</sub>O for anaesthesia sub-sector accounted for 85.7%, followed by paint application 12.1%. More 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 Source category description

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<sub>2</sub> released there are calculated.

### 5.2.2 Methodological issues

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<sub>2</sub> emission factors in Paint Application sub-sector*

	1985	BY	1986	1987	1988	1989	1990	1991	1992
<b>IEF NMVOC, t/t</b>	0.315	0.318	0.321	0.318	0.299	0.305	0.267	0.278	0.290
<b>IEF CO<sub>2</sub> t/t</b>	0.924	0.932	0.941	0.932	0.876	0.896	0.779	0.810	0.845
	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>IEF NMVOC, t/t</b>	0.255	0.241	0.224	0.381	0.361	0.283	0.277	0.263	0.252
<b>IEF CO<sub>2</sub> t/t</b>	0.737	0.693	0.641	1.115	1.051	0.806	0.790	0.744	0.709
	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>IEF NMVOC, t/t</b>	0.224	0.204	0.184	0.219	0.226	0.236	0.204	0.195	0.164
<b>IEF CO<sub>2</sub> t/t</b>	0.624	0.564	0.502	0.616	0.637	0.668	0.568	0.542	0.445

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 Source-specific QA/QC information and verification

No sector specific information is available.

#### 5.2.5 Source-specific recalculations

Last year there was no recalculation.

#### 5.2.6 Source-specific planned improvements

None.

### 5.3 Use of N<sub>2</sub>O (CRF sector 3.D)

#### 5.3.1 Source category description

This sub-sector includes less detailed technologies involving N<sub>2</sub>O 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<sub>2</sub>O cartridges is highly popular (although decreasing).

#### 5.3.2 Methodological issues

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<sub>2</sub>O production and domestic uses (tons):

Table 5.2. N<sub>2</sub>O emission (1985-2010, kt)

N <sub>2</sub> O (kt)	1985	B. Y.	1986	1987	1988	1989	1990	1991	1992
Anaesthesia	0.172	0.176	0.179	0.177	0.204	0.208	0.215	0.214	0.261
Cartridge	0.305	0.321	0.327	0.332	0.344	0.304	0.207	0.163	0.165
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Anaesthesia	0.309	0.252	0.354	0.333	0.299	0.328	0.275	0.304	0.459
Cartridge	0.167	0.137	0.145	0.137	0.131	0.113	0.096	0.071	0.061
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Anaesthesia	0.275	0.533	0.790	0.932	0.864	0.927	1.077	0.923	0.743
Cartridge	0.056	0.045	0.038	0.039	0.030	0.023	0.023	0.019	0.019

The cartridge refilling loss is high (approx. 30 %) and this is taken into account in the calculations. According to manufacturer information, N<sub>2</sub>O 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 Source-specific QA/QC information and verification

No sector specific information is available.

#### 5.3.5 Source-specific recalculation

Last year there was no recalculation.



**5.3.6 Source-specific planned improvements**

None.

## 6 AGRICULTURE (CRF sector 4.)

### 6.1 Overview of sector

Agriculture production contributed to the greenhouse gas emission through the following processes:

- 4A Enteric Fermentation by domestic livestock (CH<sub>4</sub>),
- 4B Manure Management (CH<sub>4</sub> and N<sub>2</sub>O)
- 4C Rice Cultivation (CH<sub>4</sub>),
- 4D Agricultural Soils (N<sub>2</sub>O)
- 4F Field Burning of Agricultural Residues (it has not been occurring since 1990 and therefore not reported for 1991-2010)

Category 4E Burning of Savannas is not occurring and therefore not reported in Hungary.

Main greenhouse gas emissions from Agriculture are CH<sub>4</sub> and N<sub>2</sub>O. There are no CO<sub>2</sub> emissions reported in the Agriculture sector. CO<sub>2</sub> emissions from agricultural soils are reported in the LULUCF Sector. CO<sub>2</sub> emissions from energy consumption of agricultural activities (heat production, agricultural vehicles and machinery) are reported in the Energy sector (1.AA.4C Energy, Other Sectors, Agriculture/Forestry/Fishing).

To give an overview of Hungarian agriculture the main characteristics are as follows:

Due to national conditions agriculture played a definitive role in the Hungarian economy in the past and even today. The share of agriculture in the GDP was 2.9 percent in 2010 (HCSO, 2011a). The agricultural land area was 57 percent of the total (HCSO, 2011b). According to the provisional data of the General Agricultural Census, 2010 (HCSO, 2010c), 8800 economic enterprises and 567 thousands private farms had been operated in Hungary. The farm structure of agricultural enterprises and private farms is rather different. The agricultural enterprises managed dominantly 300 ha, whereas three quarter of the private farms managed one ha or less than one ha.

Currently 2080 agricultural enterprises and 285 thousand private farms deal with animal husbandry. Although the number of private farms is more significant, the bulk of the GHG dominant livestock populations are owned by agricultural enterprises. Two third of the cattle population and three quarter of the swine population are in agricultural enterprises. The private farms are only determining in sheep farming, 85 percent of sheep population is owned by them. The agricultural enterprises and private farms play approximately an equivalent role relating to poultry farming.

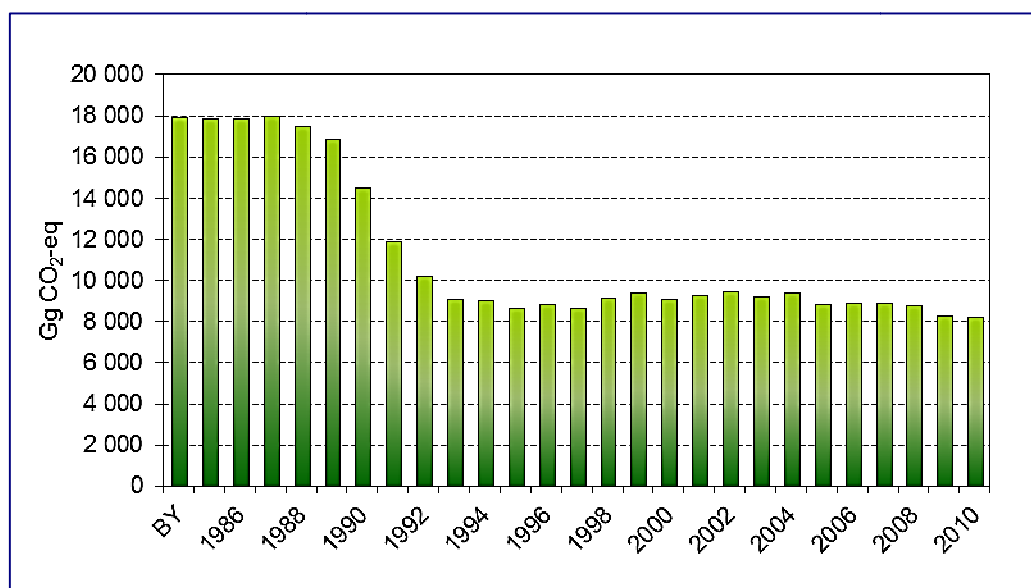
The main characteristics for trends are as follows:

In Hungary, agricultural production practically stopped growing in the late 1980's. This was followed by a dramatic drop in the 1990s, as a result of the economic and political transition taking place in the country. The gross value of agricultural production dropped, by 20 to 40 percent from the level of the 1980s. The drop was smaller for crop production (10-30%) than for animal husbandry. The output of the latter was only two third or less of the level of 1990 (Laczka and Soós, 2003). The volume index of gross agricultural production reached a minimum in 1993 of 69.1 percent of the level of 1990. The crop production has fluctuated considerably since 1993. It dropped in 2002-2003 and 2007 due to drought. In contrast, the agricultural production was relatively high due to the significantly high crop production in 2004 and 2008. The animal husbandry remained at a low level between 1993 and 2004, and has been decreasing steadily since the year of the European Union accession (2004) (Laczka, 2007).

### 6.1.1 Emission trends

In 2010, the agriculture sector contributed 12.2% of Hungary's total GHG emissions (excluding LULUCF).

The trend of emissions shows a decrease of 54% over the period of 1985-2010 as a result of decrease in activity data. The contribution of agriculture to total emissions decreased from 15.6% to its present share of 12.2% in the years 1985-2010 (see Figure 6.1 and Table 6.2). The bulk of this decrease occurred between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decrease. Between 1996 and 2008, agricultural emissions are relatively constant around 9.1 Mt with fluctuations up to 5%, and decreased by 9.9 percent in 2010 from the average of the years 1996-2008.



**Figure 6.1.** Trend in emissions from Agriculture

#### 6.1.1.1 Emission trends per gas

From 1985 to 2010 CH<sub>4</sub> emissions from agriculture decreased by 58%, N<sub>2</sub>O emissions decreased by 52%. The trends are presented in, Table 6.1, Figure 6.2 and Figure 6.3.

**Table 6.1.** Emissions of CH<sub>4</sub> and N<sub>2</sub>O from Agriculture 1985-2010

Year	GHG emissions (Gg)	
	CH <sub>4</sub>	N <sub>2</sub> O
BY	293.39	38.02
1985	300.70	37.40
1986	291.33	38.02
1987	288.16	38.62
1988	284.68	37.13
1989	275.54	35.81
1990	269.19	28.62
1991	247.34	21.61
1992	208.67	18.95
1993	182.89	17.10
1994	161.06	18.25
1995	159.29	17.22
1996	163.41	17.51
1997	156.58	17.46
1998	159.30	18.84

Year	GHG emissions (Gg)	
	CH <sub>4</sub>	N <sub>2</sub> O
1999	163.16	19.26
2000	159.61	18.60
2001	152.41	19.78
2002	153.91	20.23
2003	152.90	19.48
2004	143.20	20.61
2005	137.48	19.23
2006	134.16	19.62
2007	135.51	19.71
2008	129.45	19.66
2009	123.26	18.41
2010	122.05	18.40
Share in Hungarian total in BY	49%	69%
Share in Hungarian total in 2009	30%	85%
Trend BY-2009	-58%	-52%

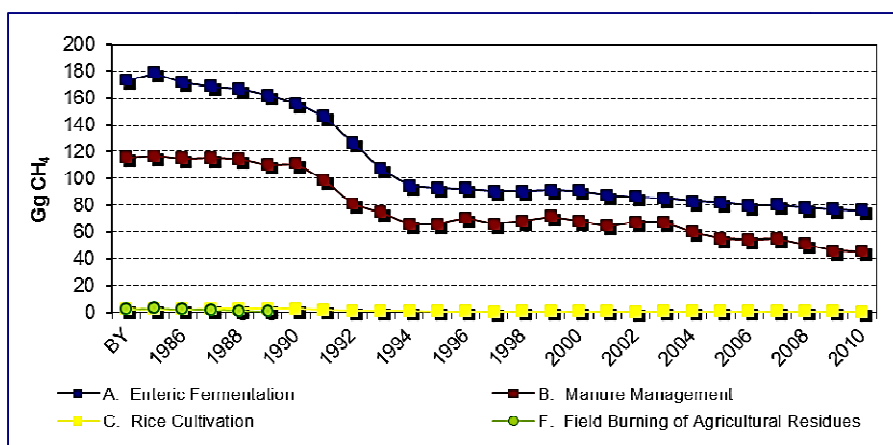


Figure 6.2. CH<sub>4</sub> emissions from Agriculture 1985-2010

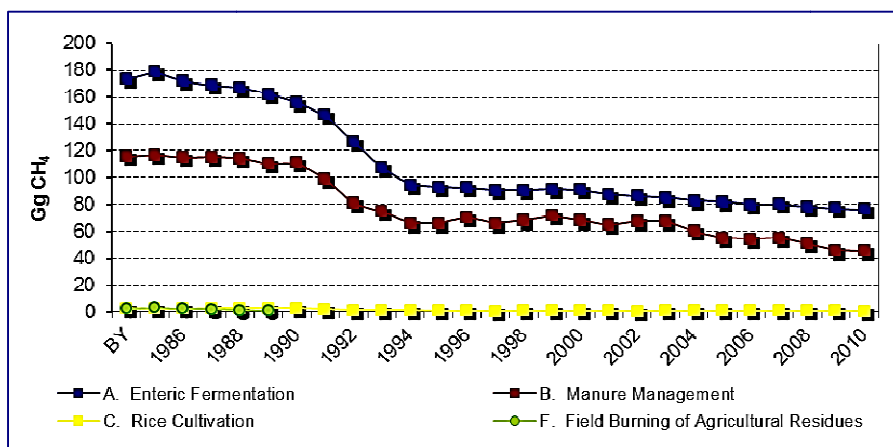


Figure 6.3. N<sub>2</sub>O emissions from Agriculture 1985-2010

### 6.1.1.2 Emission trends per subcategory

Table 6.2 and Figure 6.4 show the trends in GHG emissions by source categories as well as their contribution to the overall national emissions. The most important category is 4.D Agricultural soils at 7.1%, followed by 4.B Manure management at 2.8%, and 4.A Enteric fermentation at 2.4%. 4.C Rice cultivation accounts for the remaining less than one-tenth of a per cent.

GHG emissions amounted to 17,939 Gg CO<sub>2</sub>-eq in the BY and 8,259 Gg CO<sub>2</sub>-eq in 2010, which means a reduction of 54%. The total emission from the Agriculture sector in 2010 was the lowest over the whole time-series.

Emissions decreased significantly in the period 1991-1995 reflecting the dropping agricultural production as a result of the economic and political changes in 1990. (See Chapter 6.1) In the period 1996-2008, emissions stayed at that low level, fluctuating around approximately 9.1 million tonnes (52% of the BY). Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of nitrogen fertilizer increased by 68% until 2007, which caused growing nitrous-oxide emissions from agricultural soils.

In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels. Although fertilizer prices decreased during 2009, they stayed relatively high, especially at the beginning of the year, which led to lower synthetic fertilizer use, again. In 2010 the amount of synthetic fertilizer used slightly increased related to former years. Besides, the lower harvested production resulted in lower emissions from crop residues in agricultural soils in 2009 and 2010 compared to its high level in 2008. The overall impact of the high fertilizer prices was a 12 percent decrease in nitrogen fertilizer use from the level of 2007, which contributed to the 6 percent decrease in the emissions from agricultural soils between 2007 and 2010.

Emissions from livestock had not changed considerably between 2009 and 2010. The cattle, swine and sheep livestock decreased by 0.5, 1 and 5 per cent respectively, while the poultry population increased by 4 per cent in 2010. The slightly increasing emissions from poultry compensated the lower emissions from cattle, swine and sheep. Therefore the main driver of the slightly decreasing emissions between 2009 and 2010 is the lower emissions from crop residues as a result of the lower harvested production.

**Table 6.2. GHG emissions 1985-2010 from agriculture by subcategories**

Year	GHG emissions (GgCO <sub>2</sub> -eq)					
	4	4.A	4.B	4.C	4.D	4.F
BY	17,946	3,638	4,412	51	9,787	59
1985	17,910	3,756	4,480	47	9,551	75
1986	17,905	3,611	4,388	49	9,800	56
1987	18,025	3,547	4,370	55	10,009	45
1988	17,487	3,501	4,295	55	9,607	29
1989	16,889	3,409	4,148	50	9,266	15
1990	14,524	3,274	4,087	50	7,113	NO
1991	11,893	3,075	3,733	38	5,047	NO
1992	10,257	2,663	3,152	21	4,422	NO
1993	9,142	2,251	2,792	21	4,078	NO
1994	9,039	1,983	2,460	21	4,575	NO
1995	8,684	1,949	2,440	17	4,279	NO
1996	8,860	1,943	2,495	13	4,409	NO
1997	8,701	1,898	2,396	9	4,397	NO
1998	9,185	1,901	2,460	10	4,814	NO
1999	9,397	1,914	2,515	9	4,959	NO
2000	9,118	1,910	2,473	14	4,723	NO
2001	9,332	1,836	2,388	10	5,098	NO

Year	GHG emissions (GgCO <sub>2</sub> -eq)					
	4	4.A	4.B	4.C	4.D	4.F
2002	9,503	1,811	2,442	9	5,242	NO
2003	9,249	1,787	2,446	11	5,006	NO
2004	9,397	1,738	2,269	12	5,378	NO
2005	8,848	1,720	2,137	11	4,980	NO
2006	8,898	1,672	2,084	10	5,131	NO
2007	8,955	1,682	2,089	11	5,173	NO
2008	8,812	1,641	1,991	11	5,169	NO
2009	8,295	1,616	1,869	11	4,799	NO
2010	8,267	1,599	1,866	8	4,794	NO
Share in Hungarian total in BY	15.6%	3.2%	3.8%	0.04%	8.5%	0.1%
Share in Hungarian total in 2010	12.2%	2.4%	2.8%	0.01%	7.1%	
Trend BY-2010	-54%	-56%	-58%	-83%	-51%	100%

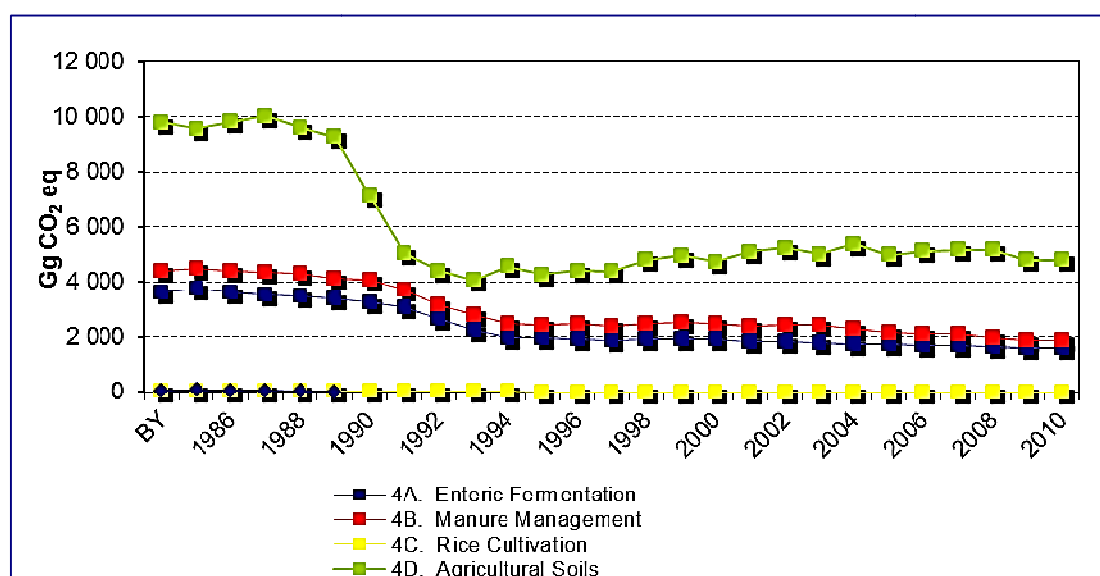


Figure 6.4. GHG emissions from Agriculture

### 6.1.2 Key Categories

Key category analysis is presented in Chapter 1.6. Table 1.2 contains the key categories of the agriculture sector.

### 6.1.3 Methodological issues

Mainly methods recommended by the Good Practice Guidance (IPCC, 2000) were applied. In some cases where the GPG (IPCC, 2000) refers to the emission factors and parameters published in the Revised Guidelines (IPCC, 1996), the latter one was used. In cases where parameters were not provided in the guidelines mentioned above, the 2006 IPCC Guidelines was applied.

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<sub>4</sub>) by all livestock categories, except Rabbits. In other categories IPCC Tier 1 method was applied. Country-specific factors were used whenever sufficient information was available, otherwise the IPCC default factors were applied. See the individual categories for further details.

### 6.1.4 Uncertainties and time-series consistency

The following chapter gives an overview of uncertainty estimates for CH<sub>4</sub> and N<sub>2</sub>O emissions from Agriculture.

Uncertainties were estimated as upper (97.5 percentile) and lower (2.5 percentile) ranges of a 95% confidence interval in this submission. Error propagation has been calculated independently for the lower and for the upper range to treat the asymmetric confidence ranges. In Table 6.4 the arithmetic mean of the upper and lower uncertainties are reported.

The uncertainty of the activity data was calculated on the basis of the available data of the HCSO, the CORINAIR Guidebook (EEA, 2007) and expert judgement; the uncertainty of the emission factors was calculated on the basis of the GPG (IPCC, 2000) recommendations. Uncertainties were combined in accordance with GPG (IPCC, 2000) Equation 6.3 and Equation 6.4.

In the Hungarian agricultural GHG inventory, the uncertainties of the Direct Soil Emissions and the Indirect Soil Emissions categories are the highest. These high values derive from the uncertainty of the activity data (to a smaller extent) and of the emission factors (to a greater extent). In accordance with the recommendation of the Guideline (IPCC, 2006) the uncertainty of the Direct and Indirect emissions from agricultural soils are reported and treated separately, because of their correlation.

The uncertainty of the livestock population data for 2010 is presented in Table 6.3. The overall uncertainty of the livestock population is lower than that in 2009, because General Agricultural Census was conducted in 2010, which is a comprehensive survey, providing the most reliable database. The overall uncertainties of the activity data, emission factors and emissions by subcategories are summarized in Table 6.4. For more details of the uncertainty assessment see the subsector chapters. The uncertainty of the N<sub>2</sub>O emissions from Agricultural soils is the IPCC default uncertainty of EF<sub>1</sub> (-80%/+380%). The uncertainty of the N<sub>2</sub>O emissions from 4.D has a significant influence on the overall uncertainty, therefore the uncertainty of EF<sub>1</sub> emission factor resulted a significant effect on the overall uncertainty of the Hungarian GHG inventory. Uncertainty analyses for the Agriculture sector had been revised for the submission 2011. As a result of this revision, the uncertainty of EF<sub>1</sub> (-80%/+380%) has been taken into account in accordance with the GPG (IPCCC, 2000) in the uncertainty assessment since the 2009 inventory year. (Formerly, a value of 250% was applied.) In the estimation of the total combined uncertainty of the national inventory, the higher values are taken into account in the case of asymmetric confidence ranges in accordance with the GPG (IPCC, 2000). 72 per cent of the national total N<sub>2</sub>O emissions are generated in agricultural soils, therefore the uncertainty of the EF<sub>1</sub> is a key driver of the combined total uncertainty. Thus the higher uncertainty of the EF<sub>1</sub> resulted in an increase of the combined total uncertainty of the Hungarian inventory between the submission 2010 and the submission 2011.

**Table 6.3. Uncertainty of animal population data for 2010 (HCSO)**

Livestock categories	Annual mean	Uncertainty of the annual mean u(AD <sub>i</sub> )	Weighted annual mean
	95% Confidence Interval (+/- 1,000 head)	%	1,000 head
Dairy Cattle	2.88	1.18	244.50
Non-Dairy Cattle	4.08	0.90	454.00
Buffalo	0.11	4.23	2.53
Sheep	51.39	4.27	1203.00
Goats	2.42	3.05	79.25
Horses	1.90	2.89	65.50
Mules and Asses	0.55	17.92	3.05
Swine	16.92	0.53	3208.00



Livestock categories	Annual mean	Uncertainty of the annual mean u(AD <sub>i</sub> )	Weighted annual mean
	95% Confidence Interval (+/- 1,000 head)	%	1,000 head
Poultry	1027.71	2.21	46587.00
Rabbit	16.13	1.76	916.25
<b>Overall (weighted mean)</b>		<b>2.13</b>	

**Table 6.4. Uncertainties of Activity Data, Emission Factors and Emissions**

4 Agriculture	GHG	Combined uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%		
4.A Enteric Fermentation	CH <sub>4</sub>	±2.1	±20 – ±50	13
4.B Manure Management	CH <sub>4</sub>	±2.1	±30 – ±50	24
4.B Manure Management	N <sub>2</sub> O	±43.4	-50/+100	77
4.C Rice Cultivation	CH <sub>4</sub>	±5	-100/+198	149
4.D.1 Direct Soil Emissions	N <sub>2</sub> O	±31.8	-80/+380	234
4.D.2 Pasture, Range and Paddock Manure	N <sub>2</sub> O	±33.4	-50/+100	87
4.D.3 Indirect Emissions	N <sub>2</sub> O	-64/+156	±50	110

Note: Uncertainty of emission factors for 4A Enteric Fermentation and 4B Manure Management CH<sub>4</sub> depends on animal species.

### 6.1.5 Quality Assurance and Quality Control

The agricultural greenhouse gas inventory is compiled by the HMS in collaboration with the Research Institute for Animal Breeding and Nutrition. The used activity data 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; 2004; ; 2010a; 2010b; 2010c). Calculation files contain checking data series. Data identity between data sources, calculation files and the CRF tables are controlled 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).

The annual sector specific QA/QC procedures are as follows:

- Check of activity data for transcription and rounding errors, comparison with original data sources;
- Re-check of activity data, comparison with the latest submission of the activity data (following the revision of the data by data supplier);
- Check of reasons for data gaps;
- Consistency check of time-series of the activity data and the estimated emissions (reasons for jumps);
- Consistency check, following the methodological changes of the data collection;
- Check of the time-series consistency of the applied livestock characterization;
- Cross-check of data sources of the activity data if it is possible (e.g. total annual milk yield per cow, and total dairy-cow population);

- Cross-check of the applied activity data between the different sub-categories;
- Check of emission factors, comparison with the IPCC default ones and comparison with the values applied by other countries according to the S&A report of the UNFCCC;
- Check of the methodologies used for the development of county-specific emission factors, comparison with the IPCC methodologies;
- Check of the correct use of the units in the calculation sheets;
- Check for transcription errors between the calculation sheets and the CRF tables;
- Consistency check of sub-categories with totals;
- Check of recalculation differences.

Since 2011 the Greenhouse Gas Division of the HMS has also been participated in the preparation of the Air Pollution Emission Inventory under the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/LRTRAP). (As a party to the UNECE/LRTRAP Convention Hungary is required to report annually data on emissions of air-pollutants covered in the Convention.) This new responsibility relating to the air pollution inventory resulted in limited resources for the QA procedures of the GHG-inventory in 2011. Nevertheless, the new data for air pollution inventory gave the opportunity to check the activity data used for the preparation of GHG-inventory to ensure the consistency between the two inventories.

Therefore the QC procedure relating to the Agriculture sector in 2011, beside the usual annual QC activity, focused on the consistency of the time-series of livestock populations and the consistency of the sub-categories of cattle and swine as well as milk yield statistics. As a result of the QC activity some inconsistencies revealed and recalculations were needed to eliminate these inconsistencies. All of the QC findings are summarised in chapter 6.1.6 together with the required recalculations.

### **6.1.6 Recalculations**

In the period 2000-2008 HCSO had produced three censuses of animal numbers per year. Since 2009 HCSO has been collected livestock population twice a year. In some cases these detailed livestock statistics were revised by the HCSO, but data revision has not yet been taken into account in the GHG inventory. Recently, the HCSO provided the revised livestock population data for the HMS, for the period 2000-2009. The detailed livestock population data used in the GHG inventory were checked and revised according to the latest HCSO's statistics.

In the GHG inventory the annual average livestock population of dairy cattle is taken into account according to the HCSO's statistics used to calculate the annual average milk yield per cow to insure the consistency between the two databases. In the course of the annual QC procedure this time series of annual average livestock population were compared with the original data of HCSO's annual censuses. The result of this comparison revealed that there is inconsistency between the animal numbers used to calculate the average annual milk yield per cow and the data of censuses for the period 1985-2003. HMS initiated a discussion with the HCSO to solve this problem. It turned out that the main reason of the inconsistency was the methodology of calculation of annual average from the data of censuses. The HCSO had calculated the annual average livestock population in an inconsistent manner for the period 1985-2003. Chronological means have been used to calculate the annual livestock population by the HCSO since 2004, but revision has not yet been made for the former years. In addition, beef cows were categorized as dairy cattle for the years 2000 and 2001.

The HCSO has revised the annual average dairy cattle population and the annual average milk yield statistics for the period 1985-2003, using chronological means, consequently. The livestock population and milk yield statistics in the GHG inventory were corrected in accordance with the HCSO's revised data.

For the other livestock categories the chronological mean has been applied to determine the

annual average livestock population since the 2004 inventory year in accordance with the HCSO's practice. The HCSO suggested using the chronological mean for the whole time series for all livestock categories, for which data is available. Therefore, cattle and swine livestock population were revised to use chronological mean for the period 1985-2003, while livestock population of sheep, goats, horses, asses and mules, poultry and rabbits were recalculated for the period 2000-2003. Chronological means cannot be applied for the latter livestock categories before 2000, because survey was taken place only once a year in the period 1985-1999.

The chronological means were applied for the different sub-categories of non-dairy cattle and swine as well. The correction of the animal number of the subcategories for non-dairy cattle resulted changes of the gross energy intake thus the country specific emission factor for enteric fermentation and CH<sub>4</sub> emission from manure management and N-excretion rate. In the case of swine the time series of the N-excretion rate was needed to recalculate according to changes of detailed animal numbers.

Following the recommendations from the in-country review of Hungary's 2010 submission, the gross energy intake for dairy cattle and N-excretion rate for swine were revised. Revision was made according to the change of the annual average milk yield and the corrected enhanced livestock characterization. In the case of the dairy cattle a new dataset on fat content of milk was also applied for the period 1998-2009. (Due to lack of this dataset, expert judgment was applied, formerly.)

Allocation of swine manure produced in pits was revised as an outcome of the in-country review of 2010 submission. Swine manure in 'Pit storage<1 month' and 'Pit storage>1 month' are now reported separately from the liquid manure. They are allocated to the 'Other' animal waste management system and for the methane conversion factor (MCF) the weighted average is now reported in accordance with the ERT encouragement.

In the course of the annual QC process an error was recognized in the calculation sheet for volatile solid excretion rate for poultry. The error has been corrected and the time-series of CH<sub>4</sub> emissions from manure management for poultry has been recalculated.

Research project on the development of country specific parameters for the estimation of N-input from crop residues of oilseed rape and sunflower has finished. The results of this research were applied for the first time in the 2012 submission.

The overall effect of the recalculations on the emissions from 4.Agriculture sector are reported in Chapter 10.4. Changes in emissions within the individual sub-categories are presented in the foregoing chapters.

### **6.1.7 Planned improvements**

Revision of the animal waste management system (AWMS) distribution data, which was planned for 2011 could not be performed, because of the preliminary data of the General Agriculture Census, 2010 provided by the HCSO were not detailed enough for the purpose of the GHG inventory. (All animal manure were reported altogether by AWMS. The manure of different animal species could not be separated.) The HMS have initiated the reprocessing of the data by the HCSO.

The inventory expert collaborates with the HCSO in the preparation of the questionnaire of the next farm structure survey, which will be conducted in 2013 to ensure the most appropriate data for greenhouse gas inventory purposes.

The revision of the AWMS distribution data will be undertaken as the reprocessed data will be available.

For this submission improvements have been made to improve the time-series consistency of the reported emissions leading to recalculations. For the next submission the improvement of the transparency are planned.

The uncertainty assessment in the Agriculture sector has a significant effect on the overall uncertainty of the Hungarian GHG inventory. Therefore the further refinement of the uncertainty assessment, using Monte Carlo simulation is planned in the Agriculture sector.

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

### 6.2.1 Source Category Description

Emitted gas: CH<sub>4</sub>

Key source: Level 1; Trend 1;

Enteric fermentation in animals is considered as significant source of CH<sub>4</sub> all over the world. The most important process of generation is anaerobic cellulose degradation in the rumen of ruminants. Some CH<sub>4</sub> is generated in the colon of horses and rabbits, and in the caecum of poultry. In Hungary the leading CH<sub>4</sub> 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<sub>4</sub> from enteric fermentation. In 2010 62% of the entire CH<sub>4</sub> 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 (IPCC, 2000), except for the Dairy Cattle and the Non-Dairy Cattle categories, where country specific emission factors were used in accordance with the Tier 2 method of GPG (IPCC, 2000).

#### 6.2.2.2 Activity Data - Livestock Population

The time-series of annual average livestock populations (Table 6.5) was calculated from the two separate census data surveyed by the HCSO, annually. The HCSO produces two censuses of animal numbers per year, one in June and the other in December. The annual average population for a year *t* was calculated by using the chronological mean of census data, as follows:

$$\text{NoA}_t = (0.5 \cdot \text{NoA}_{\text{Dec},t-1} + \text{NoA}_{\text{June},t} + 0.5 \cdot \text{NoA}_{\text{Dec},t}) / 2 \quad (\text{Equation 6.1.})$$

Where:

NoA<sub>t</sub> = chronological mean of the annual population of a livestock category in a year *t* [1'000 head]

NoA<sub>Dec,t-1</sub> = population of a livestock category in December of the year *t*-1 [1'000 head]

NoA<sub>June,t</sub> = population of a livestock category in June of the year *t* [1'000 head]

NoA<sub>Dec,t</sub> = population of a livestock category in December of the year *t* [1'000 head]

It has to be noted that, until the end of 2008 the HCSO collected data on animal livestock population three times a year, (April, August and December). For the calculation of the annual average population the chronological mean was used, similarly.

**Table 6.5. Livestock population 1985-2010**

Year	Animal Population (1,000 head)									
	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
1985	603	1,310	0.1	2,588	18	103	5.0	9,050	82,030	2,238
BY	590	1,234	0.1	2,498	19	99	5.0	8,963	82,816	2,319
1986	584	1,226	0.1	2,454	18	100	5.1	8,904	83,502	2,319
1987	582	1,165	0.1	2,453	22	93	5.0	8,935	82,914	2,400
1988	581	1,144	0.1	2,327	26	80	4.8	8,888	79,079	2,481
1989	574	1,116	0.1	2,172	31	79	4.6	8,540	74,591	2,562
1990	564	1,053	0.1	1,958	35	80	4.5	8,709	69,846	2,644
1991	527	1,018	0.1	2,009	39	84	4.3	7,809	57,540	2,978

Year	Animal Population (1,000 head)									
	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
1992	480	834	0.1	1,867	50	79	4.3	6,237	52,746	2,755
1993	436	649	0.1	1,458	61	75	4.3	5,805	44,013	2,096
1994	409	554	0.1	1,089	71	85	4.3	5,007	46,264	1,271
1995	395	549	0.2	998	76	75	4.3	5,023	45,092	1,378
1996	389	546	0.3	930	81	74	4.3	5,494	38,873	1,041
1997	388	521	0.4	901	86	76	4.3	5,013	45,874	933
1998	381	494	0.5	954	90	77	4.3	5,247	46,620	1,005
1999	385	489	0.6	981	95	78	4.3	5,609	40,722	912
2000	363	479	0.7	1,192	97	78	3.6	5,146	48,562	791
2001	353	443	0.8	1,163	107	68	3.5	4,823	51,074	1,087
2002	345	434	0.9	1,138	97	63	3.4	5,050	51,334	1,180
2003	330	433	1.0	1,227	95	63	3.3	5,078	52,486	1,089
2004	309	424	1.1	1,380	85	65	3.2	4,385	50,492	1,182
2005	300	420	1.2	1,447	78	67	3.0	4,022	46,405	1,003
2006	275	428	1.3	1,358	81	65	2.3	3,944	44,653	1,084
2007	268	442	1.4	1,301	72	59	2.1	4,039	43,160	1,055
2008	264	436	1.4	1,270	73	58	2.0	3,665	45,033	904
2009	258	444	1.5	1,261	65	60	1.9	3,248	44,789	871
2010	245	454	2.5	1,203	79	66	3.1	3,208	46,587	916
<b>Trend BY-2010</b>	<b>-59%</b>	<b>-63%</b>	<b>2425%</b>	<b>-52%</b>	<b>310%</b>	<b>-34%</b>	<b>-40%</b>	<b>-64%</b>	<b>-44%</b>	<b>-60%</b>

Source: HCSO 1985-2010

### 6.2.2.3 Emission Factors

#### 6.2.2.3.1 Cattle

Emissions of CH<sub>4</sub> from enteric fermentation in Dairy Cattle and Non-Dairy Cattle categories were calculated using the Tier 2 method (GPG, Equation 4.14):

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

(Equation 6.2)

Where:

EF	CH <sub>4</sub> emission factor [kg head <sup>-1</sup> yr <sup>-1</sup> ]
GE	gross energy intake [MJ head <sup>-1</sup> day <sup>-1</sup> ]
Y <sub>m</sub>	methane conversion rate [MJ MJ <sup>-1</sup> ]
365	days of year [day yr <sup>-1</sup> ]
55.65	energy content of methane [MJ kg <sup>-1</sup> ]

**Gross energy intake (GE)** – Gross energy intakes for cattles and non-dairy cattles were determined as follows. The average body mass of dairy-cattles was determined for each year of the time-series by expert judgement (Várhegyi 2007, Györkös 2010, Bölcskey 2010) based on the change of the livestock composition. In the 70-ies the Hungarian cattle herd consisted mainly of double used cows (Hungarian Simmental) and partly dairy cattle having smaller body mass (Jersey, Ayrshire). Since 1970 this cattle herd has been changed, continuously, crossing the above mentioned species with Holstein Friesian cattle. In 1985 the Hungarian cattle herd consisted mainly of Holstein-Friesian and Holstein-Friesian Cross-bred, but the Hungarian Simmental and Jersey Ayrshire species also had an importance. Since 1985 the proportion of the latter ones species has been dropped. The milk yield increased from 4518 kg per year to 6429 kg per year in the period 1985-2005. It is known from the literature, that the selection for the increase of milk yield results in increase of body mass as well. The 1985 and 2005 values of body mass was estimated at 600 kg and 650 kg,

respectively, based on the literature. In the period 1985-2005 the annual body mass was estimated using linear interpolation. No growth in body mass was calculated for the period of 2006-2009.

The daily average milk yield (18.84 kg per day in 2010) was calculated based on the HCSO's annual milk yield statistics (see Table 6.7).

A characteristic total mixed ration (TMR) was calculated for each year of the time-series using the WINLP (Hungarian nutrition optimization software for dairy cow, Várhegyiné et al., 2007) according to the requirements of a dairy cow having the estimated annual average body mass and the daily average milk yield. The GE-content of the composed feed ration was applied for the estimation of the annual value of the emission factor.

The estimation was refined using a new, country-specific fat and nutrition content of the milk dataset for the period 1998-2010, while constant fat and protein contents of 3.71 and 3.29% were applied for the period 1985-1997 using the average of the values reported for the period 1998-2010, due to lack of data. The annual milk fat and nutrition content statistics are published on the website of the Hungarian Dairy Product Council.

Input Data and Output Results of the WINLP runs are presented in Table 6.6.



**Table 6.6.** *Input data and output results of the WINLP runs for the estimation of GE for Dairy-Cattle*

Year	WINLP Input Data				WINLP Output Results				
	Body Mass, Average	Milk yield, Average	Fat Content of Milk	Protein Content of Milk	DM (Dry Matter)	CP (Crude Protein)	NE (Netto Energy)	Conc. Ratio	Forage Ratio
	kg head <sup>-1</sup>	kg day <sup>-1</sup>	%	%	kg day <sup>-1</sup>	g head <sup>-1</sup> day <sup>-1</sup>	MJ head <sup>-1</sup> day <sup>-1</sup>	%	%
1985	600	12.38	3.71	3.29	14.6	1,778.2	87.3	14.7	85.3
1986	603	13.03	3.71	3.29	14.8	1,840.3	89.6	16.1	83.9
1987	605	13.29	3.71	3.29	14.9	1,865.6	90.5	16.5	83.5
1988	608	13.69	3.71	3.29	15.0	1,904.5	92.0	17.4	82.6
1989	610	13.74	3.71	3.29	15.1	1,910.3	92.3	17.7	82.3
1990	613	13.89	3.71	3.29	15.2	1,926.2	93.0	18.1	81.9
1991	615	13.12	3.71	3.29	15.0	1,855.9	90.6	17.0	83.0
1992	618	13.33	3.71	3.29	15.1	1,877.1	91.4	17.6	82.4
1993	620	12.98	3.71	3.29	15.0	1,845.9	90.4	17.2	82.8
1994	623	13.11	3.71	3.29	15.1	1,859.8	91.0	17.6	82.4
1995	625	13.77	3.71	3.29	15.3	1,922.2	93.3	18.7	81.3
1996	628	13.64	3.71	3.29	15.3	1,911.9	93.0	18.7	81.3
1997	630	14.03	3.71	3.29	15.4	1,949.3	94.4	19.5	80.5
1998	633	15.09	3.66	3.33	15.7	2,040.8	97.7	30.0	70.0
1999	635	14.94	3.70	3.28	15.8	2,035.0	97.6	21.1	78.9
2000	638	15.01	3.67	3.25	15.8	2,038.1	97.8	21.2	78.8
2001	640	15.52	3.66	3.29	15.9	2,084.6	99.5	22.5	77.5
2002	643	16.87	3.67	3.28	16.4	2,212.8	104.1	25.0	75.0
2003	645	16.86	3.62	3.18	16.3	2,203.4	103.9	24.9	75.1
2004	648	16.80	3.72	3.30	16.5	2,218.9	104.6	25.3	74.7
2005	650	17.61	3.61	3.21	16.6	2,273.2	106.5	26.3	73.7
2006	650	18.31	3.71	3.28	17.0	2,858.2	109.5	27.9	72.1
2007	650	18.83	3.91	3.31	17.5	2,449.3	112.9	29.5	70.5
2008	650	19.10	3.67	3.23	17.2	2,422.7	111.8	28.9	71.1
2009	650	18.74	3.79	3.37	17.2	2,415.1	111.6	28.8	71.2
2010	650	18.84	3.83	3.42	17.3	2,433.1	112.3	29.3	70.7

Note: values in italics are the average of the values reported for the period 1998-2005, due to lack of data.

To estimate the GE-intake for Non-Dairy Cattle a detailed livestock population's statistics (HCSO, 1985-2010) reflecting the age structure and animal performance was used. As a first step the average body mass for the livestock sub-categories were determined by expert judgment (Bölcskey, 2010). The average body mass for the Non-Dairy Cattle was calculated as the weighted average of the estimated mass of the different sub-categories for each year. The applied livestock sub-categories and their typical body mass are listed below:

Cattle less than one year old

*Calves for slaughter, male (250 kg)*

*Calves for slaughter, female (240 kg)*

*Other calves, male (290 kg)*

*Other calves, female (270 kg)*

Cattle aged between one and two

*Male (550 kg)*

*Female for slaughter (heifers) (510 kg)*

*Female, other (500 kg)*



Cattle of two years and over

Male (650 kg)

Female for slaughter (heifers) (550 kg)

Other, heifers (550 kg)

Cows, beef (650 kg)

The average body mass of the category varied between 404 kg and 442 kg in the period of 1985-2010. The average body mass of non-dairy cows was 439 kg in 2010.

In the second step the dry matter intake was calculated from the average body mass using the Equation 6.3. This regression equation was determined in accordance with the Hungarian Nutrition Codex, 2004.

$$y=0.0131x+2.2821, R^2=0.09988$$

Equation 6.3

where,

y= Dry matter intake (kg day<sup>-1</sup>)

x= Average body mass (kg)

R<sup>2</sup>= Determination coefficient

The daily dry matter intake multiplied by the energy content of feed (18.45 MJ/kg DM) gives the daily average GE-intake.

**Methane conversion rate (Y<sub>m</sub>)** – In the case of Dairy Cattle the methane conversion rate is assumed to be lower than the default value given in Table 4.8 of GPG (IPCC, 2000). For 2010 0.0578 [MJ MJ<sup>-1</sup>] was assumed, and for the period 1985-2009 the methane conversion rate was in the range of 0.0578-0.0595, because of the high concentrate/forage ratio characteristic in Hungary. Table 4.8 of GPG (IPCC, 2000) provides Y<sub>m</sub> value between 0.055 and 0.065 (0.060 ± 0.005), depending on the composition (concentrate / forage ratio), quality and digestibility of the feed ration. In Hungary the dairy cattle population generally receives good quality TMR feed, depending on the dairy production level, along with relatively high concentrate ratio.

The feed ration of a dairy cow having the average milk yield and average body mass was compiled for each year of the time-series. The concentrate/ forage ratios were also calculated for each year. The Y<sub>m</sub> value was estimated on the basis of the concentrate %, which turned to be slightly below the IPCC default value for 1985 (concentrate % = 14.5, Y<sub>m</sub> = 0.0595). As regards 2005, concentrate % increased to 26.3% and the Y<sub>m</sub> value was estimated as 0.0581. The Y<sub>m</sub> value was interpolated for the years between 1985 and 2005, and extrapolation was carried out for 2006-2010.

In the case of Non-Dairy Cattle category the IPCC default value of 0.06 MJ MJ<sup>-1</sup> was used in the Tier 2 calculations (Table 6.7).

**Table 6.7.** Annual milk yield, gross energy intake, methane conversion rate and emission factors for Dairy Cattle and Non-Dairy Cattle 1985-2010

Year	Dairy Cattle				Non-Dairy Cattle		
	Milk Yield	Gross Energy Intake	Methane Conversion Rate [Y <sub>m</sub> ]	CH <sub>4</sub> -Emission Factor	Gross Energy Intake	Methane Conversion Rate [Y <sub>m</sub> ]	CH <sub>4</sub> -Emission Factor
	[kg cow <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[%]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[%]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1985	4,481	273.58	5.95	106.77	148.93	6	58.61
BY	4,671	279.35	5.95	108.92	148.83	6	58.57
1986	4,713	280.50	5.94	109.33	148.74	6	58.53
1987	4,821	283.96	5.94	110.68	148.81	6	58.56
1988	4,926	287.42	5.94	111.88	148.35	6	58.38
1989	4,972	288.99	5.93	112.35	147.50	6	58.05
1990	5,031	291.19	5.92	113.07	146.04	6	57.47

Year	Dairy Cattle				Non-Dairy Cattle		
	Milk Yield	Gross Energy Intake	Methane Conversion Rate [ $Y_m$ ]	CH <sub>4</sub> -Emission Factor	Gross Energy Intake	Methane Conversion Rate [ $Y_m$ ]	CH <sub>4</sub> -Emission Factor
	[kg cow <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[%]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[%]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1991	4,711	282.70	5.91	109.63	144.95	6	57.04
1992	4,780	285.22	5.91	110.47	142.67	6	56.14
1993	4,757	284.91	5.90	110.20	141.90	6	55.84
1994	4,716	284.28	5.89	109.82	140.31	6	55.22
1995	4,991	292.45	5.88	112.84	139.90	6	55.05
1996	5,064	294.97	5.88	113.66	140.24	6	55.19
1997	5,112	296.86	5.87	114.24	140.26	6	55.20
1998	5,513	307.55	5.86	118.21	140.42	6	55.26
1999	5,454	306.92	5.85	117.81	139.94	6	55.07
2000	5,886	319.18	5.85	122.36	140.67	6	55.36
2001	6,051	323.90	5.84	124.01	140.04	6	55.11
2002	6,155	327.36	5.83	125.18	139.72	6	54.98
2003	6,154	326.73	5.82	124.77	140.27	6	55.20
2004	6,131	328.93	5.82	125.45	142.52	6	56.08
2005	6,429	334.91	5.81	127.57	142.76	6	56.18
2006	6,706	344.97	5.80	131.23	144.37	6	56.82
2007	6,874	355.03	5.79	134.88	145.34	6	57.20
2008	6,972	351.57	5.79	133.40	145.95	6	57.44
2009	6,815	350.31	5.78	132.75	146.19	6	57.53
2010	6,877	353.14	5.78	133.82	148.14	6	58.30

#### 6.2.2.3.2 Other livestock categories

The emission factors used for enteric fermentation in buffalo, sheep, goats, horses, asses and mules are the IPCC default ones provided for developed countries. In the case of rabbit and poultry the IPCC methodologies do not provide emission factors. Emissions from enteric fermentation in rabbits are relatively small, accounting for 0.09 percent of the total emissions from enteric fermentations in all livestock. Therefore development of a country-specific emission factor does not seem to be reasonable. The emission factor provided by the Italian NIR, 2008 is used, because Italy is the nearest neighbor of Hungary, who reports emissions from rabbits.

The HMS has initiated the revision of the emission factor used for rabbits as an outcome of the centralized review of the 2010 submission. The revision will be undertaken by the Research Institute for Animal Breeding and Nutrition using the existing research results relating to the rabbit husbandry. Because of the low relative importance of the contribution to the total emissions of rabbits new research project do not seem to be reasonable.

For poultry the emission factor was taken from the literature, due to lack of IPCC default values. Sources of emission factors per livestock species are summarized in Table 6.8.

**Table 6.8.** Emission factors used for the calculation of the methane emissions from enteric fermentation

Animal category	CH <sub>4</sub> -emission factor [kg head <sup>-1</sup> yr <sup>-1</sup> ]	Comments
Dairy Cattle	see Table 6.7	country specific value, Tier 2
Non-Dairy Cattle	see Table 6.7	country specific value, Tier 2
Buffalo	55	IPCC default value for developed countries

Animal category	CH <sub>4</sub> -emission factor [kg head <sup>-1</sup> yr <sup>-1</sup> ]	Comments
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 the NIR of Italy, 2008

### 6.2.3 Uncertainties and time-series consistency

Uncertainty of activity data (animal population) was estimated for each animal species for the data collection period by the HCSO. The uncertainty of the mean annual averages was estimated according to the error propagation rules. (See Table 6.4) For the uncertainty of the country specific EFs  $\pm 20\%$  were assumed, while for the default EFs  $\pm 50\%$  was applied in accordance with the GPG (IPCC, 2000). The combined uncertainty of the emissions from the 4.A sector is  $\pm 13$  per cent.

### 6.2.4 QA/QC Information

See 6.1.5.

### 6.2.5 Source-specific recalculations

As an effect of the QA/QC procedure the livestock populations was revised to ensure the time series consistency and to correct the data in accordance with the HCSO's data revisions, with a particular focus on the cattle and swine populations, both having substantial impact on the agricultural GHG emissions. (See also Chapter 6.1.6.) Recalculations resulted in changes in the reported livestock population as well their emissions for the period 1985-2003 and 2007-2008. Changes in the annual average livestock population are shown in Table 6.9.

Country-specific emission factors relating to dairy and non-dairy cattle were revised as a result of the reconsideration of gross energy intake. The GE for dairy cattle was recalculated according to the revised milk yield statistics and using a new fat and nutrition content statistics. Change in the annual average milk yield, the GE and the emission factors are presented in Table 6.10. In the case of dairy-cattle the revision of GE was done as an outcome of the in-country review of 2010 submission while in the case of non-dairy cattle recalculation was needed due to the inconsistencies revealed in the course of QA/QC procedure. This revision improved the consistency of the emission estimation from enteric fermentation for non-dairy cattle, significantly.

**Table 6.9.** Changes in the reported livestock population between the submission 2012 and submission 2011

Year	Animal Number [1,000 head]								
	Dairy Cattle	Non-Dairy Cattle	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
1985	4.91	11.97	0.00	0.00	0.00	0.00	119.63	0.00	0.00
BY	4.42	5.46	0.00	0.00	0.00	0.00	42.54	0.00	0.00
1986	5.42	-0.29	0.00	0.00	0.00	0.00	-50.88	0.00	0.00

Year	Animal Number [1,000 head]								
	Dairy Cattle	Non-Dairy Cattle	Sheep	Goats	Horses	Asses and Mules	Swine	Poultry	Rabbits
1987	2.93	4.69	0.00	0.00	0.00	0.00	58.88	0.00	0.00
1988	8.13	-11.38	0.00	0.00	0.00	0.00	-13.88	0.00	0.00
1989	4.38	7.12	0.00	0.00	0.00	0.00	83.38	0.00	0.00
1990	3.74	-0.37	0.00	0.00	0.00	0.00	-42.50	0.00	0.00
1991	8.16	10.72	0.00	0.00	0.00	0.00	250.88	0.00	0.00
1992	7.87	24.75	0.00	0.00	0.00	0.00	78.63	0.00	0.00
1993	-1.53	21.53	0.00	0.00	0.00	0.00	45.38	0.00	0.00
1994	5.45	5.67	0.00	0.00	0.00	0.00	80.63	0.00	0.00
1995	2.18	-4.43	0.00	0.00	0.00	0.00	-66.00	0.00	0.00
1996	-6.42	11.17	0.00	0.00	0.00	0.00	-42.83	0.00	0.00
1997	0.33	9.17	0.00	0.00	0.00	0.00	59.67	0.00	0.00
1998	-0.17	-0.33	0.00	0.00	0.00	0.00	-91.33	0.00	0.00
1999	-0.03	4.03	0.00	0.00	0.00	0.00	24.00	0.00	0.00
2000	-27.16	35.82	-32.50	-0.69	-0.17	0.18	83.50	-952.57	-128.17
2001	-24.03	27.70	-1.17	-0.50	2.50	-0.07	2.00	-1,042.33	-50.83
2002	-0.19	2.36	5.50	0.67	-0.50	0.02	-43.33	395.00	23.00
2003	0.01	5.16	-32.17	0.17	0.17	-0.02	28.17	-1,064.17	-58.83
2004	0.00	0.33	0.00	0.00	0.00	0.08	0.00	0.00	182.67
2005	0.00	0.00	0.00	0.00	0.00	0.35	0.00	-0.33	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.17	-0.17	0.17	0.00	0.50	0.00	1.83	-2.50	0.00
2008	0.17	-0.17	0.17	-0.33	0.50	0.00	1.83	-2.50	0.00
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

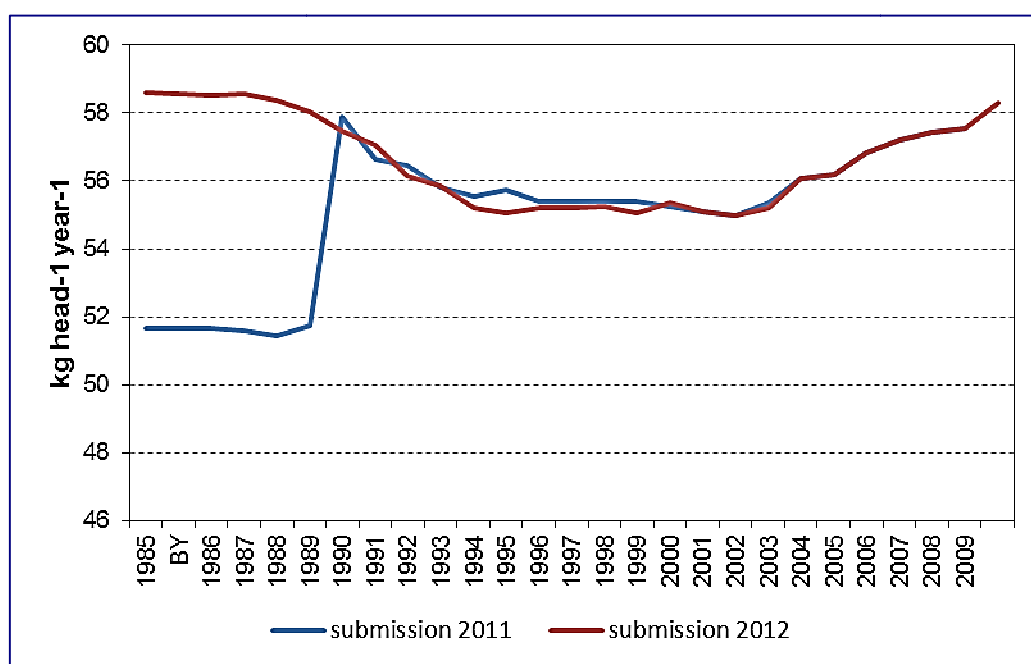
Note: Values reported in the submission 2011 are subtracted from the values reported in the submission 2012.

**Table 6.10.** Changes in the milk yield, gross energy intake and emission factor for enteric fermentation between the submission 2012 and the submission 2011

Year	Dairy-Cattle			Non-Dairy Cattle	
	Milk Yield	Gross Energy Intake	CH <sub>4</sub> -Emission Factor	Gross Energy Intake	CH <sub>4</sub> -Emission Factor
	[kg cow <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1985	-37	1.00	0.40	17.67	6.95
BY	-37	1.03	0.44	17.61	6.91
1986	-44	0.81	0.32	17.48	6.87
1987	-29	1.26	0.63	17.68	6.96
1988	-70	0.12	0.19	17.66	6.95
1989	-43	0.81	0.46	16.05	6.32
1990	-37	0.97	0.52	-1.07	-0.42
1991	-78	-0.10	0.10	1.02	0.40
1992	-85	-0.25	0.05	-0.74	-0.30
1993	19	2.61	1.14	0.03	0.01
1994	-70	0.10	0.18	-0.85	-0.33
1995	-34	1.26	0.63	-1.72	-0.68

Year	Dairy-Cattle			Non-Dairy Cattle	
	Milk Yield	Gross Energy Intake	CH <sub>4</sub> -Emission Factor	Gross Energy Intake	CH <sub>4</sub> -Emission Factor
	[kg cow <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[MJ head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1996	87	4.53	1.89	-0.56	-0.22
1997	-8	2.11	0.95	-0.54	-0.21
1998	6	1.54	0.75	-0.38	-0.15
1999	0	2.05	0.93	-0.86	-0.34
2000	407	13.08	5.16	0.29	0.12
2001	386	12.26	4.85	0.02	0.01
2002	-6	1.42	0.71	-0.04	-0.02
2003	0	0.63	0.40	-0.44	-0.17
2004	0	2.89	1.26	0.00	0.00
2005	0	0.32	0.29	0.00	0.00
2006	24	3.11	1.35	0.00	0.00
2007	0	7.73	3.11	0.00	0.00
2008	0	1.38	0.70	0.00	0.00
2009	-26	3.33	1.27	0.00	0.00

Note: Values reported in the submission 2011 are subtracted from the values reported in the submission 2012.



**Figure 6.5.** The effect of the recalculation on the emission factor for CH<sub>4</sub> emissions from enteric fermentation in non-dairy cattle

The overall effect of the recalculations on the CH<sub>4</sub> emissions from 4.A Enteric Fermentation are presented in Table 6.11. The percentage changes in CH<sub>4</sub> emissions range between 0.00 to 6.34 per cent. The highest change refers to 1985.

**Table 6.11.** *The net effect of the recalculations of CH<sub>4</sub> emissions from 4.A Enteric Fermentation*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CH <sub>4</sub> ]	163.6	168.2	162.9	159.8	158.4	154.0	155.7	144.1	124,6
Submission 2012 [Gg CH <sub>4</sub> ]	173.2	178.9	172.0	168.9	166.7	162.3	155.9	146.4	126,8
Difference [Gg CH <sub>4</sub> ]	9.6	10.7	9.1	9.1	8.4	8.3	0.2	2.3	2,2
Percentage change	5.9%	6.3%	5.6%	5.7%	5.3%	5.4%	0.1%	1.6%	1,7%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CH <sub>4</sub> ]	105.6	93.5	93.0	92.1	89.5	90.5	90.7	90.4	87,0
Submission 2012 [Gg CH <sub>4</sub> ]	107.2	94.4	92.8	92.5	90.4	90.5	91.2	90.9	87,4
Difference [Gg CH <sub>4</sub> ]	1.6	0.9	-0.2	0.5	0.9	0.0	0.4	0.6	0,4
Percentage change	1.5%	1.0%	-0.2%	0.5%	1.0%	0.0%	0.5%	0.6%	0,5%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CH <sub>4</sub> ]	85.9	85.0	82.3	81.8	79.3	79.2	77.9	45.8	
Submission 2012 [Gg CH <sub>4</sub> ]	86.2	85.1	82.8	81.9	79.6	80.1	78.2	45.8	
Difference [Gg CH <sub>4</sub> ]	0.3	0.1	0.4	0.1	0.4	0.9	0.2	0.0	
Percentage change	0.4%	0.1%	0.5%	0.1%	0.5%	1.1%	0.3%	0.0%	

### 6.2.6 Planned improvements

Revision of the emission factor used for rabbits as an outcome of the centralized review of the 2010 submission is planned for the next inventory cycle. The revision will be undertaken by the Research Institute for Animal Breeding and Nutrition using the existing research results relating to the rabbit husbandry. (These emissions have minor importance in the Hungarian agricultural GHG inventory; therefore instigating a new research project does not seem to be reasonable.)

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

### 6.3.1 Source Category Description

Emitted gas: CH<sub>4</sub>

Key source: Level 1; Trend 1;

Emitted gas: N<sub>2</sub>O

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

Animal manure is an important source of CH<sub>4</sub> and N<sub>2</sub>O. The amount of CH<sub>4</sub> and N<sub>2</sub>O 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 2010 37% (CH<sub>4</sub>) and 16% (N<sub>2</sub>O) of the agricultural emissions arose from this source category.

### 6.3.2 Methodological issues

#### 6.3.2.1 Calculation method

CH<sub>4</sub> emissions from manure management (excluding Rabbits category) were estimated by using the Tier 2 methodology.

N<sub>2</sub>O emissions from manure management were calculated by applying Tier 1 methods, although in the case of the annual N-excretion, country specific data were used for dairy cattle, non-dairy cattle and swine.

#### 6.3.2.2 Activity data

**Number of Livestock** - See chapter 6.2.2.2 and Table 6.5 regarding livestock activity data.

**Annual average Nitrogen excretion rates (N<sub>ex</sub>)** – country specific parameters were used for Dairy Cattle, Non-Dairy Cattle Swine, based on Fébel and Gundel (2007).

In the case of dairy cattle this study provides N-excretion rates per body mass for four milk yield categories. The annual N-excretion rates were calculated from the values of the provided N-excretion rates per body mass and daily milk yield category, multiplied by the body mass. The N-excretion rates per body mass given by the study were used to calculate the country-specific Nitrogen excretion rates for non-dairy cattle and swine as well.

In the case of the other livestock categories the default values provided by Table 4-20, on p. 4.99 in the Revised Guidelines, Ref. Man., Table 4-20, p. 4.99 were used. For horses and goats, which are not listed in the above mentioned table, values were taken from the literature (Walther et al., 1994) and in the case of rabbit; the value provided by the EMEP-Corinair Guidebook (EEA, 2002) was applied. Values of nitrogen excreted and their sources are showed in Table 6.12 and Table 6.13).

**Typical Body Mass of Livestock Categories** – see 6.2.2.3 for the estimation of the typical body mass of the Dairy Cattle and the Non-Dairy Cattle categories. As regards swine population the HCSO's detailed livestock data and the body mass of the subcategories based on expert judgment (Egerszegi, 2010) were used. The typical body mass of the swine population was determined annually as the weighted average of the body masses of the subcategories as follows:

Piglets under 20 kg (average 11 kg)

Young pigs, 20-50 kg (average 35 kg)

Pigs for fattening over 50 kg

    Pigs for fattening over 50-79 kg (average 65 kg)

    Pigs for fattening over 80-109 kg (average 95 kg)

    Pigs for fattening 110 kg and over 110 kg (average 120 kg)

Breeding sows

    Breeding sows in farrowing (180 kg)

    Breeding sows, draft (180 kg)

Sows mated for the first time (180 kg)

Gilts not yet mated (76 kg)

Breeding boars (210 kg)

The average body mass of the category varied between 63 kg and 70 kg in the period of 1985-2010.

**Manure Management System Distribution** – 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 allocation of the nitrogen generated in 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). These estimations 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 conditions of buildings and equipment. This survey allows conclusions to be drawn in connection with the entire animal management sector because it covers 70% to 100% of the livestock populations depending on the given category.

The concrete values used for emission calculations were determined on the basis of the ratios of places provided in the study (Ráki 2003) and of personal expert consultations (György Mészáros, Ministry for Agriculture and Rural Development, 2000, verbal communication). The following tables of the study served as the basis of the calculations:

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 livestock categories the expert judgement of Mészáros (2000) was used.

The allocation of animal manure per AWMS systems data were updated by a new survey for sheep and goats for 2009. To provide reliable data on the features of sheep production relating to GHG emissions, a survey using sampling approach were carried out by the Research Institute for Animal Breeding and Nutrition in 2010. The sampling was based on questionnaires and on-site surveys. The selected farms for this survey represented all kind of technology and size of farms characteristic in the sheep sector in Hungary. 75 farms were measured by questionnaires and 10 farms were examined on-site. This survey covers 95 thousands animal places. Besides the sheep farms also two goat farms were surveyed on-site. The survey results were published by Borka et al. in 2010.

In accordance with this study (with exception of grazing) only solid systems has been used in manure management for sheep and goat since 2009. Table 6.12, Table 6.13,

Table 6.14, and summarise the data on the estimation of average annual nitrogen emissions of the individual livestock categories and the amounts of nitrogen excreted in the various manure management systems.

**Table 6.12.** Annual average Nitrogen excretion rates ( $N_{ex}$ ) for Dairy Cattle, Non-Dairy Cattle and Swine 1985-2010

Year	Dairy Cattle	Non-Dairy Cattle	Swine
	[kg head <sup>-1</sup> yr <sup>-1</sup> ]		
1985	91.78	49.13	9.51
BY	93.27	49.08	9.51
1986	93.50	49.03	9.47
1987	94.52	49.08	9.56
1988	95.52	48.83	8.79
1989	96.18	48.45	8.67
1990	96.92	47.76	8.57
1991	95.43	47.24	8.76
1992	96.23	46.19	8.78
1993	96.48	45.81	8.73
1994	96.63	45.02	8.75
1995	98.66	44.83	8.72
1996	99.50	45.03	8.58

Year	Dairy Cattle	Non-Dairy Cattle	Swine
[kg head <sup>-1</sup> yr <sup>-1</sup> ]			
1997	100.18	45.01	7.96
1998	103.01	45.06	7.86
1999	103.06	44.83	8.06
2000	106.11	45.23	8.07
2001	107.53	44.93	7.98
2002	108.60	44.77	7.94
2003	109.01	45.13	8.13
2004	109.29	46.29	8.21
2005	111.57	46.48	8.13
2006	113.30	47.32	8.02
2007	114.34	47.79	8.03
2008	114.95	48.17	8.13
2009	113.98	48.27	8.07
2010	114.36	49.24	8.17

Source: Expert judgements (Gundel 2004, Várhegyi 2004, Fébel 2007) and literature data (Várhegyiné et al. 1999, Babinszky et al. 2002, Fébel and Gundel 2007) it was assumed 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.

**Table 6.13.** Annual average Nitrogen excretion rates ( $N_{ex}$ ) for Buffalo, Sheep, Goats, Horses, Asses and Mules and Poultry

Animal Category	$N_{ex}$ [kg head <sup>-1</sup> year <sup>-1</sup> ]	Comments
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
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.

**Table 6.14.** Allocation of animal manure per AWMS, volatile solid excretion rate, maximum methane producing capacity and  $CH_4$ -emission factors for Manure Management (I)

Allocation [%]	Animal category				
	Dairy cattle	Non-dairy cattle	Buffalo	Sheep	Goats
Pasture range and paddock	8	15	40	40	40
Solid storage and dry lot	88.08	83.18	60	60	60
Liquid system	3.92	1.82	-	-	-
VS (Volatile Solid Excretion Rate) [kg DM day <sup>-1</sup> ]	see Table 6.18	see Table 6.18	3.90	0.40	0.28
$B_0$ (Max $CH_4$ -producing capacity) [m <sup>3</sup> kg <sup>-1</sup> VS]	0.24	0.17	0.10	0.19	0.17
$CH_4$ -emission factor [kg head <sup>-1</sup> yr <sup>-1</sup> ]	see Table 6.18	see Table 6.18	0.95	0.25	0.12

**Table 6.15.** Allocation of animal manure per AWMS, volatile solid excretion rate, maximum methane producing capacity and CH<sub>4</sub>-emission factors for Manure Management (II)

Allocation [%]	Animal category				
	Horses	Asses and Mules	Swine	Total Poultry	Rabbits
Pasture range and paddock	40	40	-	-	-
Solid storage and dry lot	60	60	25	74	100
Liquid system	-	-	25	26	-
Pit storage <1 month	-	-	25	-	-
Pit storage >1 month	-	-	25	-	-
VS (Volatile Solid Excretion Rate) [kg DM day <sup>-1</sup> ]	1.72	0.94	0.50	0.019	-
B <sub>0</sub> (Max CH <sub>4</sub> -producing capacity) [m <sup>3</sup> kg <sup>-1</sup> VS]	0.33	0.33	0.45	0.32	-
CH <sub>4</sub> -emission factor [kg head <sup>-1</sup> yr <sup>-1</sup> ]	1.39	0.76	10.87	0.16	0.08

Note that Pit storage is reported together with the Other system in the CRF table 4.B(a)s2.

### 6.3.2.3 Emission factors

#### 6.3.2.3.1 Emission factors for CH<sub>4</sub>

CH<sub>4</sub> emission factors for manure management were calculated in accordance with the GPG (IPCC, 2000) (Equation 4.17):

$$EF_i = VS_i \cdot 365 \cdot B_{oi} \cdot 0.67 \cdot \sum_{(jk)} MCF_{jk} \cdot MS_{ijk} \quad (\text{Equation 6.3})$$

Where

EF<sub>i</sub> emission factor for livestock population i [kg head<sup>-1</sup> yr<sup>-1</sup>]

VS<sub>i</sub> volatile solid excretion for livestock population i [kg head<sup>-1</sup> day<sup>-1</sup>]

365 Factor-1 [day yr<sup>-1</sup>]

B<sub>oi</sub> maximum CH<sub>4</sub> producing capacity for manure produced by animals in livestock population i [m<sup>3</sup> kg<sup>-1</sup> VS]

0.64 Factor-1 [kg m<sup>-3</sup>]

MCF<sub>jk</sub> CH<sub>4</sub> conversion factors for each manure management system j by climate region k [kg kg<sup>-1</sup>]

MS<sub>ijk</sub> fraction of animal species/category i's manure handled using manure system j in climate region k

Table 6.18 and Table 6.19 contains parameters used for the calculations (VS, B<sub>o</sub>, MCF, MS) and the CH<sub>4</sub> emission factors.

**Volatile solid excretion per day (VS)** – VS for “Dairy Cattle” and “Non-Dairy Cattle” was calculated according to the GPG (IPCC, 2000) (Equation 4.16, page 4.31).

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

Where

VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm head<sup>-1</sup> day<sup>-1</sup>

GE = Estimated daily average feed intake in MJ head<sup>-1</sup> day<sup>-1</sup>

DE = Digestible energy of the feed in percent

ASH = Ash content of the manure in percent

The gross energy intake (GE) was calculated on the basis provided in Chapter 6.2.2.3. The feed digestibility was estimated based on the concentrate feeding level, as shown in Table 6.16.

**Table 6.16.** Relationship between the concentrate feeding level and digestible energy of food

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

In the case of poultry the volatile solid excretion rates for each year were determined according to the livestock composition. The poultry category in the Hungarian agricultural inventory contains layers, broilers, turkeys, ducks, geese and guinea fowl populations. The annual values of VS for the poultry population were determined as the overall weighted mean of the VS values provided in the Table 10A.9 of the Guidelines (IPCC, 2006). In the case of geese and guinea fowl IPCC default values for VS are not provided, therefore values provided for ducks and broilers were used, respectively. The annual livestock population and VS values for the subcategories of poultry are shown in Table 6.17.

**Table 6.17.** Animal population and VS for poultry livestock in 2010

Livestock	Annual population in 2010	VS/day [kgVS]
	[1000 head]	
Chicken	23,164	0.01
Laying hen	12,545	0.02
Geese	2,211	0.02
Ducks	103,1	0.02
Turkeys	5,155	0.07
Guinea fowls	148	0.01
Total poultry	46,587	0.019

For other livestock categories the IPCC default values of VS provided by the Table B-2 and B-7 in the Rev. Guidelines (IPCC, 1996) were used.

**Maximum CH<sub>4</sub> producing capacity (B<sub>0</sub>) values** – since there are no country specific values available, in accordance with the recommendation of the GPG (IPCC, 2000), the default values listed in Appendix B-4 of the Rev Guidelines (IPCC, 1996) were used.

**CH<sub>4</sub> conversion factors (MCF)** – since there are no country specific values available, the IPCC default values (GPG 2000, Table 10, 4.36. p.) were used.

**Ash content** - In the case of “Ash content” of the manure in percent (ASH)” the IPCC default value (8%) was used (GPG 2000, 4.31. p.).

Table 6.18 and Table 6.19, summarise the data on volatile solid excretion rates, methane conversion factors and CH<sub>4</sub>-emission factors for Manure Management.

**Table 6.18.** Volatile solid excretion rates and CH<sub>4</sub>-emission factors for Manure Management for Dairy Cattle and Non-Dairy Cattle 1985-2010

Year	Dairy Cattle		Non-Dairy Cattle	
	Volatile Solid Excretion Rate (VS)	CH <sub>4</sub> -Emission Factor	Volatile Solid Excretion Rate (VS)	CH <sub>4</sub> -Emission Factor
	[kg DM day <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[kg DM day <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1985	4.77	6.98	2.97	2.09
BY	4.88	7.13	2.97	2.09
1986	4.90	7.16	2.97	2.09
1987	4.96	7.25	2.97	2.09
1988	5.02	7.34	2.96	2.08
1989	5.04	7.38	2.94	2.07
1990	4.72	6.90	2.91	2.05
1991	4.58	6.70	2.89	2.04
1992	4.98	7.28	2.85	2.00
1993	4.97	7.27	2.83	1.99
1994	4.96	7.25	2.80	1.97
1995	5.10	7.46	2.79	1.96
1996	4.78	6.99	2.80	1.97
1997	5.18	7.58	2.80	1.97
1998	4.98	7.29	2.80	1.97
1999	4.97	7.27	2.79	1.96
2000	5.17	7.56	2.81	1.97
2001	5.25	7.68	2.79	1.97
2002	5.31	7.76	2.79	1.96
2003	4.89	7.15	2.80	1.97
2004	4.92	7.20	2.84	2.00
2005	5.01	7.33	2.85	2.00
2006	5.16	7.55	2.88	2.03
2007	5.31	7.77	2.90	2.04
2008	5.26	7.69	2.91	2.05
2009	5.24	7.66	2.92	2.05
2010	5.28	7.72	2.95	2.08

**Table 6.19.** Methane conversion factors for manure management systems

Manure Management System	MCF [kg kg <sup>-1</sup> ]
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
Other	0.01

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

Note that Pit storage is reported together with the Liquid system in the CRF table 4.B(a)s2.

### 6.3.2.3.2 Emission factors for N<sub>2</sub>O

Since there are no country specific factors available, the IPCC default emission factors were used (Table 6.20).

**Table 6.20.** Emission factors used for the estimation of the N<sub>2</sub>O emission from various manure management systems

Manure management system	N <sub>2</sub> O-N emission factor [kg N <sub>2</sub> O-N kg <sup>-1</sup> N <sub>ex</sub> ]
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

Note that Pit storage is reported together with the Liquid system in the CRF table 4.B(a)s2.

## 6.3.3 Uncertainties and time-series consistency

### 6.3.3.1 CH<sub>4</sub> emissions

Uncertainty of activity data (animal population) was estimated for each animal species for the data collection period by the HCSO. The uncertainty of the mean annual averages was estimated according to the error propagation rules. (See Table 6.4)

Uncertainty of EFs for CH<sub>4</sub> emissions from manure management was assumed to be ±30%, for all livestock categories, except rabbit, for which ±50% was applied. The Rev. Guideline (IPCC, 1996) suggests ±20%, the Guideline (IPCC, 2006) provides ±30% for the T1 and ±20% for T2 methods, while the CORINAIR Guidebook (EEA, 2006) suggests ±30%, therefore the ±30% is more reliable for the country-specific emission factors. The Tier1 uncertainty analysis gives an overall uncertainty of ±24 % for the CH<sub>4</sub> emission from manure management.

### 6.3.3.2 N<sub>2</sub>O emissions

Uncertainties of ±25% are assumed in relation to the N excretion of dairy cattle's, non-dairy cattle's and swine, for which country-specific values are used, and ±50% for the other livestock categories in accordance with the GPG (IPCC, 2000). The uncertainty of the MS data was assumed to be ±25% in accordance with the default value provided by Guideline (IPCC, 2006). The combined uncertainties of the excreted N in the different AWMSs range between 20 and 35 percent. (The smaller value refers to the Solid system, the higher one to the Pit storage system.) The uncertainty of the EFs are -50%/+100%, therefore the lower combined uncertainty of the N<sub>2</sub>O emissions from Manure management is 53% and the upper one is 100%.

### 6.3.4 QA/QC Information

See 6.1.5.

### 6.3.5 Source-specific recalculations

Revised gross energy intake for cattle resulted changes in the VS, whereby the emission factors for CH<sub>4</sub> emissions have also changed.

As a result of the QA/QC procedure an error in the calculation sheet for volatile solid excretion rate for poultry was found. The error has been corrected and the time-series of CH<sub>4</sub> emissions from manure management for poultry has been recalculated.

The reconsideration of N-excretion (Table 6.21) rate for cattle and swine resulted changes in the N<sub>2</sub>O emissions from 4.B Manure Management for the whole time series.

**Table 6.21.** *Changes in the reported N-excretion rates between the submission 2012 and submission 2011*

Year	Dairy Cattle	Non-Dairy Cattle	Swine
	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]	[kg head <sup>-1</sup> yr <sup>-1</sup> ]
1985	-0.21	8.04	0.00
BY	-0.21	8.02	-0.01
1986	-0.25	7.95	0.02
1987	-0.17	8.05	-0.04
1988	-0.41	8.04	0.12
1989	-0.25	7.30	-0.09
1990	-0.22	-0.83	0.16
1991	-0.46	0.47	-0.10
1992	-0.50	-0.27	0.49
1993	0.12	0.05	0.11
1994	-0.42	-0.37	0.06
1995	-0.20	-0.80	0.00
1996	0.52	-0.23	0.25
1997	-0.05	-0.25	0.01
1998	0.04	-0.20	0.00
1999	0.00	-0.43	-0.03
2000	2.49	0.17	0.01
2001	2.37	0.01	-0.01
2002	-0.03	-0.02	0.04
2003	0.00	-0.24	-0.06
2004	0.00	0.00	0.00
2005	0.00	0.00	0.00
2006	-18.13	0.00	0.00
2007	-17.49	0.00	0.00
2008	-17.10	0.00	0.01
2009	-17.79	0.00	0.00

Note: Values reported in the submission 2011 are subtracted from the values reported in the submission 2012.

The overall effect of the recalculations on the emissions from 4.B is not significant. The percentage changes in CH<sub>4</sub> emissions range between 0.00 to 1.96 per cent in 2008-2009 and 1998, respectively. (The average of the changes is 0.6 per cent.) The percentage changes in N<sub>2</sub>O emissions range between 0.01 to 4.94 per cent, in 2005 and 1985, respectively. (The average of the changes is 1.27 per cent.)

The overall effect of the recalculations is shown in Table 6.22 and Table 6.23.



**Table 6.22.** *The net effect of the recalculations of CH<sub>4</sub> emissions from 4.B Manure Management*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CH <sub>4</sub> ]	115.6	116.1	115.9	114.7	114.9	109.5	112.5	97.5	80.6
Submission 2012 [Gg CH <sub>4</sub> ]	115.6	116.8	114.9	115.0	114.2	110.2	110.9	99.1	80.9
Difference [Gg CH <sub>4</sub> ]	0.0	0.7	-0.9	0.3	-0.7	0.8	-1.6	1.6	0.3
Percentage change	0.0%	0.6%	-0.8%	0.2%	-0.6%	0.7%	-1.5%	1.7%	0.3%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CH <sub>4</sub> ]	74.7	64.9	66.6	71.0	65.2	69.7	71.6	67.3	64.7
Submission 2012 [Gg CH <sub>4</sub> ]	74.7	65.6	65.7	70.3	65.8	68.3	71.6	68.0	64.5
Difference [Gg CH <sub>4</sub> ]	0.0	0.7	-0.9	-0.7	0.5	-1.4	-0.1	0.7	-0.1
Percentage change	0.0%	1.1%	-1.4%	-1.0%	0.8%	-2.0%	-0.1%	1.1%	-0.2%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CH <sub>4</sub> ]	67.4	67.2	59.8	55.0	54.0	54.8	50.7	45.8	
Submission 2012 [Gg CH <sub>4</sub> ]	67.3	67.3	59.9	55.0	54.0	54.9	50.8	45.8	
Difference [Gg CH <sub>4</sub> ]	-0.2	0.2	0.1	0.0	0.0	0.1	0.0	0.0	
Percentage change	-0.2%	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	

**Table 6.23.** *The net effect of the recalculations of N<sub>2</sub>O emissions from 4.B Manure Management*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg N <sub>2</sub> O]	6.1	6.2	6.1	6.0	5.9	5.7	5.7	5.3	4.6
Submission 2012 [Gg N <sub>2</sub> O]	6.4	6.5	6.4	6.3	6.1	5.9	5.7	5.3	4.7
Difference [Gg N <sub>2</sub> O]	0.3	0.3	0.3	0.3	0.3	0.2	0.0	0.1	0.1
Percentage change	4.5%	4.9%	4.3%	4.3%	4.3%	4.0%	-0.1%	1.0%	1.6%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg N <sub>2</sub> O]	3.9	3.5	3.4	3.3	3.3	3.3	3.3	3.4	3.4
Submission 2012 [Gg N <sub>2</sub> O]	3.9	3.5	3.4	3.3	3.3	3.3	3.3	3.4	3.3
Difference [Gg N <sub>2</sub> O]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage change	0.8%	0.6%	-0.5%	0.2%	0.4%	-0.3%	0.0%	-1.3%	-1.0%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg N <sub>2</sub> O]	3.3	3.4	3.2	3.2	3.1	3.0	3.0	2.9	
Submission 2012 [Gg N <sub>2</sub> O]	3.3	3.3	3.3	3.2	3.1	3.0	3.0	2.9	
Difference [Gg N <sub>2</sub> O]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Percentage change	0.3%	-0.9%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	

### **6.3.6 Planned improvements**

Revision of data on the distribution 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 will be based on the data of General Agricultural Census conducted in 2010.

(See also 6.1.9.)

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

### **6.4.1 Source Category Description**

Emitted gas: CH<sub>4</sub>

Key source: none

Hungary is situated on the north edge of the 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<sub>4</sub> 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<sub>4</sub> m<sup>-2</sup>; SF<sub>0</sub>= 2; SF<sub>s</sub>=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 6.1.6. and Table 6.4.

For the uncertainty of the activity data, ±5% has been estimated by expert judgement. Uncertainties of the factors used for the calculation of the emission factor were taken from the GPG (IPCC, 2000). (SF<sub>w</sub> -60%/+40%; SF<sub>0</sub> -25%/150%; EF<sub>C</sub> -40%/+40%; SF<sub>s</sub> -90%/+100%. Therefore the overall lower and upper uncertainty of 100% and 198% can be calculated for the emission from rice cultivation.

### **6.4.4 QA/QC Information**

See 6.1.5.

### **6.4.5 Source-specific recalculations**

Recalculation was not required.

### **6.4.6 Planned improvements**

-

## 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<sub>2</sub>O

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

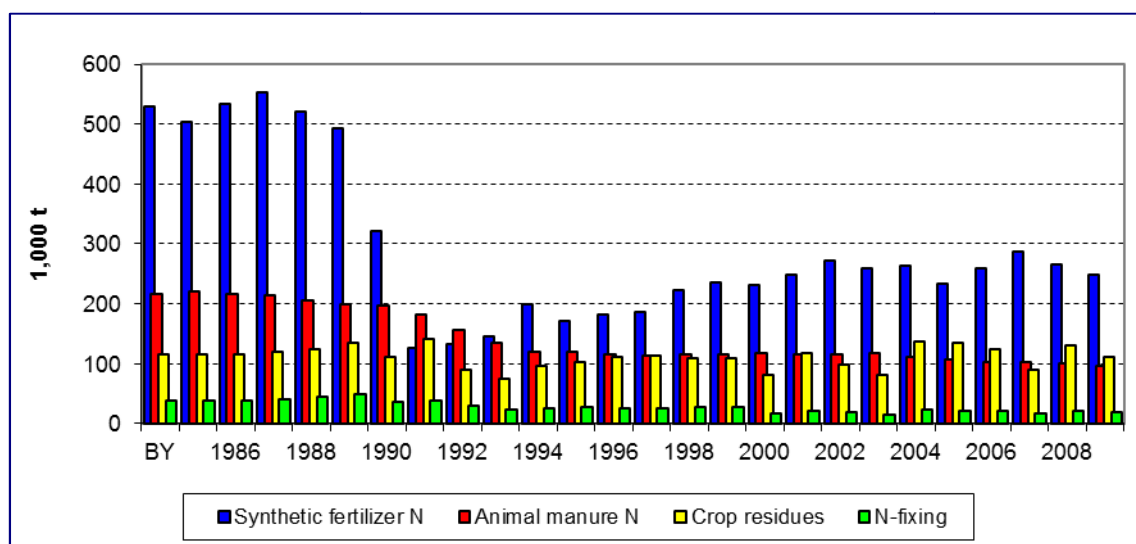
In 2010 agricultural soils emitted 84% of the total N<sub>2</sub>O emissions of the agriculture sector, and 72% of the national total N<sub>2</sub>O emissions are generated in agricultural soils. Emissions from the agricultural soils contributed 7.1 percent (4,786 Gg CO<sub>2</sub>-eq) to the Hungarian total GHG emissions in 2010. (See Table 6.2.)

The trend in emissions is decreasing. The emissions from Agricultural soils have decreased to 51 percent of the 1985-1987 levels in 2010. A significant drop occurred in the period 1985-1993 due to significant decrease in livestock population and synthetic fertilizer use which resulted in less N-input (Figure 6.6). For more details on trends see also Chapter 6.1.1.

Emissions from 4.D Agricultural soils and their trends per sub-categories are shown in Table 6.24.

**Table 6.24. Emissions and trends from the 4.D Agricultural Soils per sub-categories**

Year	N <sub>2</sub> O emissions (Gg N <sub>2</sub> O)							
	4.D.1	4.D.1.1	4.D.1.2	4.D.1.3	4.D.1.4	4.D.2	4.D.3.1	4.D.3.2
1985	17.9	10.4	4.4	0.8	2.3	1.9	10.7	1.9
BY	17.4	9.9	4.5	0.8	2.2	1.9	10.4	1.9
1986	17.9	10.5	4.4	0.7	2.3	1.9	10.7	1.9
1987	18.3	10.9	4.4	0.8	2.3	1.9	10.9	1.9
1988	17.7	10.2	4.2	0.9	2.5	1.8	10.3	1.8
1989	17.3	9.7	4.0	0.9	2.6	1.8	9.8	1.8
1990	13.1	6.3	3.9	0.7	2.2	1.4	7.5	1.4
1991	9.6	2.5	3.6	0.8	2.8	1.0	4.7	1.0
1992	8.1	2.6	3.1	0.6	1.8	0.9	4.4	0.9
1993	7.5	2.8	2.7	0.5	1.5	0.9	4.2	0.9
1994	8.7	3.9	2.4	0.5	1.9	0.9	4.6	0.9
1995	8.2	3.4	2.3	0.5	2.0	0.8	4.2	0.8
1996	8.6	3.6	2.3	0.5	2.2	0.8	4.3	0.8
1997	8.6	3.6	2.2	0.5	2.2	0.8	4.3	0.8
1998	9.3	4.4	2.3	0.5	2.1	0.9	4.8	0.9
1999	9.6	4.6	2.3	0.5	2.1	0.9	5.0	0.9
2000	8.8	4.6	2.3	0.3	1.6	0.9	5.0	0.9
2001	9.8	4.9	2.2	0.4	2.3	0.9	5.1	0.9
2002	9.9	5.4	2.3	0.4	1.9	1.0	5.5	1.0
2003	9.3	5.1	2.3	0.3	1.6	1.0	5.3	1.0
2004	10.5	5.2	2.2	0.4	2.7	1.0	5.3	1.0
2005	9.7	4.6	2.1	0.4	2.6	0.9	4.9	0.9
2006	9.9	5.1	2.0	0.4	2.4	0.9	5.1	0.9
2007	9.7	5.7	2.0	0.3	1.7	1.0	5.5	1.0
2008	10.1	5.2	2.0	0.4	2.5	0.9	5.1	0.9
2009	9.2	4.9	1.9	0.4	2.1	0.9	4.9	0.9
2010	9.1	5.0	1.9	0.4	1.9	0.9	4.9	0.9
<b>Trend BY-2010</b>	<b>49%</b>	<b>52%</b>	<b>57%</b>	<b>53%</b>	<b>18%</b>	<b>87%</b>	<b>54%</b>	<b>54%</b>



**Figure 6.6.** Trends from N-inputs from synthetic fertilizer, animal manure, crop residues and N-fixing

### 6.5.2 Methodological issues

The estimation of direct and indirect N<sub>2</sub>O emissions was carried out on the basis of the GPG (IPCC, 2000) using the Tier 1b method, Equation 4.29 (IPCC, 2000).

The activity data such as livestock population (Table 6.5) for calculating N-excretion, total harvested production of plants (Table 6.26), synthetic N-fertilizer use (Table 6.25) were obtained directly from the database of the HCSO.

**Table 6.25.** Synthetic fertilizer use (1985-2010)

Year	Synthetic fertilizer use (1,000 t)
BY	589
1985	558
1986	593
1987	614
1988	579
1989	548
1990	358
1991	140
1992	148
1993	161
1994	222
1995	191
1996	203
1997	206
1998	248
1999	262
2000	258
2001	275
2002	303
2003	289
2004	293
2005	260
2006	289

Year	Synthetic fertilizer use (1,000 t)
2007	320
2008	294
2009	275
2010	281

Source: HCSO, 2010

N<sub>2</sub>O emissions from the categories of Direct Soil Emissions (from synthetic N-fertilizer, animal manure, N-fixing, crop residues), Emissions from Pasture, Range and Paddock Manure and Indirect Soil Emissions were calculated with the parameters summarized in Table 6.14 and Table 6.15. In order to calculate the amount of N from animal manure use and on pastures the data presented in Table 6.12 and Table 6.13 (see chapter 6.3.2) were also used beside Table 6.26.

The parameters used for the calculation of N fixed by N fixing crops and N-input from crop residues were selected on the basis of the GPG (IPCC, 2000) default values (Table 4.16, Page 4.58). In the case of crops that are not listed in the above mentioned table, the parameters for similar type of crop were chosen (e.g. the factors for bean in the case of French bean). If default residue nitrogen content were not provided in Table 4.16, the non-crop specific default value listed in Table 4-19 of the Rev. Guideline (IPCC, 1996) was applied.

**Table 6.26.** Parameters and values used for the calculation of N<sub>2</sub>O emissions from Agricultural Soils

Parameter	Dimension	Value
<b>Direct Soil Emissions – Synthetic Fertilizer</b>		
Frac <sub>GASF</sub>	kg kg <sup>-1</sup>	0.1
F <sub>SN</sub>	kg yr <sup>-1</sup>	GPG Eq-4.22
EF <sub>1</sub>	kg kg <sup>-1</sup>	0.0125
<b>Direct Soil Emissions – Animal Manure</b>		
Frac <sub>GASM</sub>	kg kg <sup>-1</sup>	0.2
Frac <sub>FUEL-AM</sub>	kg kg <sup>-1</sup>	0
Frac <sub>PRP</sub> (2009)	kg kg <sup>-1</sup>	0.126
Frac <sub>FEED-AM</sub>	kg kg <sup>-1</sup>	0
Frac <sub>CNST-AM</sub>	kg kg <sup>-1</sup>	0
F <sub>AM</sub>	kg yr <sup>-1</sup>	GPG Eq-4.24
EF <sub>1</sub>	kg kg <sup>-1</sup>	0.0125
<b>Direct Soil Emissions – N-Fixing</b>		
Res <sub>BF</sub> /Crop <sub>BF</sub>		Table 6.27
Frac <sub>DM</sub> N-fixing-crops		Table 6.27
Frac <sub>NRCBF</sub>		Table 6.27
F <sub>BN</sub>		Table 6.27
Non-forage Crops	kg yr <sup>-1</sup>	GPG Eq-4.26
Forage Crops	kg yr <sup>-1</sup>	GPG Eq-4.27
EF <sub>1</sub>	kg kg <sup>-1</sup>	0.0125

Direct Soil Emissions – Crop Residues		
Res <sub>0</sub> /Crop <sub>0</sub>		Table 6.27
Frac <sub>DM</sub> , N-fixing and Non-N-fixing Crops		Table 6.27
Frac <sub>NCR0</sub>		Table 6.27
Res <sub>BF</sub> /Crop <sub>BF</sub>		Table 6.27
Frac <sub>NCRBF</sub>	kg kg <sup>-1</sup>	Table 6.27
Frac <sub>BURN</sub>	kg kg <sup>-1</sup>	0
Frac <sub>BURN</sub> for Cereals 1985-1989		0.1103-0.0220
Frac <sub>FUEL-CR</sub>	kg kg <sup>-1</sup>	0
Frac <sub>CNST-CR</sub>	kg kg <sup>-1</sup>	0
Frac <sub>FOD</sub>	kg kg <sup>-1</sup>	0
F <sub>CR</sub>	kg yr <sup>-1</sup>	GPG Eq-4.26
EF <sub>1</sub>	kg kg <sup>-1</sup>	0.0125
Direct Soil Emissions – Pasture, Range and Paddock Manure		
Frac <sub>PRP</sub> (2010)	kg kg <sup>-1</sup>	0.127
EF <sub>3</sub>	kg kg <sup>-1</sup>	0.02
Indirect Soil Emissions – Atmospheric deposition		
Frac <sub>GASF</sub>	kg kg <sup>-1</sup>	0.1
Frac <sub>GASM</sub>	kg kg <sup>-1</sup>	0.2
EF <sub>4</sub>	kg kg <sup>-1</sup>	0.01
Indirect Soil Emissions – Leaching and Run-Off		
Frac <sub>LEACH</sub>	kg kg <sup>-1</sup>	0.3
EF <sub>5</sub>	kg kg <sup>-1</sup>	0.025

**Table 6.27.** Crop production statistics for 2010 and parameters used to estimate emissions from N-fixing and crop residues

Crop	Annual Crop Product	Residue/Crop Product Ratio	Dry Matter Fraction	Nitrogen Fraction
	[t]	[t/t]	[t/t]	[t N/ t dm]
Wheat	3,745,190	1.3	0.85	0.0028
Meslin	59	1.3	0.85	0.0028
Maize	6,984,872	1	0.78	0.0081
Rice	5,893	1.4	0.85	0.0067
Barley	943,817	1.2	0.85	0.0043
Rye	78,170	1.6	0.9	0.0048
Oats	117,879	1.3	0.92	0.007
Triticale	366,823	1.3	0.85	0.0028
Other cereals	19,293	1.3	0.85	0.0028
Potatoes	488,406	0.4	0.85	0.011
Bean	545	2.1	0.855	0.023
Peas	36,597	1.5	0.87	0.0142
Lentil	57	2.1	0.855	0.023
Broad bean	196	2.1	0.855	0.023
Lupin	25	2.1	0.855	0.023
Soybeans	85,440	2.1	0.865	0.023
Sunflower seed	969,718	3	0.8	0.0057
Oilseed rape	530,619	2	0.7	0.0033

Crop	Annual Crop Product	Residue/ Crop Product Ratio	Dry Matter Fraction	Nitrogen Fraction
	[t]	[t/t]	[t/t]	[t N/ t dm]
<i>Linseed</i>	339	1	0.85	0.015
<i>Poppy seed</i>	7,410	1	0.85	0.015
<i>Sugar-beet</i>	818,941	0.3	0.85	0.0228
<i>Lucerne seed</i>	138	1.3	0.85	0.015
<i>Seeds of grass</i>	1,372	1.3	0.85	0.015
<i>Tomatoes</i>	134,274	0.4	0.85	0.011
<i>Cucumber</i>	37,989	0.4	0.85	0.011
<i>Watermelon</i>	141,086	0.4	0.85	0.011
<i>Melon</i>	8,593	0.4	0.85	0.011
<i>Green peas</i>	17,034	1.5	0.87	0.0142
<i>Green beans/ French beans</i>	61,075	2.1	0.855	0.023
<i>Sweet pepper</i>	109,533	0.4	0.85	0.011
<i>Bonnet pepper</i>	11,923	0.4	0.85	0.011
<i>Sweet corn</i>	302,757	1	0.78	0.0081
<i>Hungarian red paprika</i>	14,460	0.4	0.85	0.011
<i>Lucerne hay</i>	586,890	0	0.85	0.015
<i>Red clover hay</i>	13,174	0	0.85	0.015

### 6.5.3 Uncertainties and time-series consistency

For the uncertainty of the synthetic fertilizer nitrogen  $\pm 5\%$  has been estimated by expert judgment. Uncertainty for  $\text{Frac}_{\text{GASF}}$  ( $\pm 50\%$ ) was taken from the CORINAIR Guidebook (EEA, 2007). The combined uncertainty of the  $\text{F}_{\text{SN}}$  is 50%. A combined uncertainty of  $\pm 79\%$  can be estimated for  $\text{F}_{\text{AM}}$ . (Combined uncertainty of 15.7% resulted for the total N excreted by livestock, the uncertainty for the  $\text{Frac}_{\text{GASM}}$  is -75%/ +100% in accordance with the GPG (IPCC, 2000). The uncertainty estimation of the  $\text{F}_{\text{BN}}$  resulted in  $\pm 40\%$ , while the uncertainty of the  $\text{F}_{\text{CR}}$   $\pm 25\%$  was taken from the CORINAIR Guidebook (EEA, 2006) due to lack of detailed information. The resulting uncertainty for the activity data of the direct soil emission is 31.5%. The uncertainty of the emission factor is -80%/ +380% in accordance with the GPG (IPCC, 2000). The resulting uncertainty ranges for the direct emission of the agricultural soil from 86% to 381%. The resulting uncertainty ranges for the indirect emission of the agricultural soil from 72% to 149%.

### 6.5.4 QA/QC Information and verification

For the general procedure of the QC see 6.1.5.

### 6.5.5 Source-specific recalculations

Revised livestock number and N-excretion rates resulted in recalculation of the 4.D.1.2 for the whole time-series.

As a result of a research project on crop residues of oil rapeseed and sunflower country-specific parameters, was introduced in the 4.D.1.4. The IPCC guidelines do not provide default residue to crop product ratio, dry matter fraction and nitrogen fraction for these crops, therefore expert judgments were applied, formerly. The new country-specific parameters resulted in changes in the emission from 4.D.1.4 for the whole time-series.

Recalculated parameters have changed as follows (Table 6.28):



**Table 6.28.** *Changes of crop residue statistics for oilseed rape and sunflower seed*

Crops	Residue/Crop Product Ratio		Dry Matter Fraction		Nitrogen Fraction	
	Submission 2011	Submission 2012	Submission 2011	Submission 2012	Submission 2011	Submission 2012
Oilseed rape	1	2	0.85	0.7	0.0150	0.0033
Sunflower seed	1	3	0.85	0.8	0.0150	0.0057

The overall effect of the recalculations on the emissions from 4.D is presented in Table 6.29. The percentage changes in emissions range between 0.01 to 1.34 per cent, referring to 2004 and 1985, respectively.

**Table 6.29.** *The overall effect of the recalculations on N<sub>2</sub>O emissions from 4.D Agricultural Soils*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg N <sub>2</sub> O]	31.2	30.4	31.3	32.0	30.7	29.6	22.9	16.2	14.1
Submission 2012 [Gg N <sub>2</sub> O]	31.6	30.8	31.6	32.3	31.0	29.9	22.9	16.3	14.3
Difference [Gg N <sub>2</sub> O]	0.4	0.4	0.3	0.3	0.3	0.3	0.0	0.1	0.2
Percentage change	1.1%	1.3%	1.0%	1.0%	1.1%	1.0%	0.0%	0.6%	1.2%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg N <sub>2</sub> O]	13.1	14.7	13.8	14.2	14.2	15.6	16.0	15.3	16.5
Submission 2012 [Gg N <sub>2</sub> O]	13.2	14.8	13.8	14.2	14.2	15.5	16.0	15.2	16.4
Difference [Gg N <sub>2</sub> O]	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Percentage change	0.5%	0.3%	-0.2%	0.2%	0.1%	-0.2%	-0.2%	-0.4%	-0.3%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg N <sub>2</sub> O]	16.9	16.2	17.3	16.1	16.6	16.7	16.8	15.6	
Submission 2012 [Gg N <sub>2</sub> O]	16.9	16.1	17.3	16.1	16.6	16.7	16.7	15.5	
Difference [Gg N <sub>2</sub> O]	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	
Percentage change	0.0%	-0.3%	0.0%	-0.2%	-0.2%	-0.3%	-0.4%	-0.5%	

### 6.5.6 Planned improvements

No improvements are planned for the next inventory cycle.

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

### 6.6.1 Source Category Description

Emitted gases: CH<sub>4</sub>, N<sub>2</sub>O

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 Government Decree No.

21/2001. (II. 14.), which 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). This Government Decree has been amended at the end of 2010, therefore the Government Decree No. 306/2010. (XII.14.) is in force relating to field burning of agricultural residues, currently. 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 into 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:  $\text{Frac}_{\text{BURN}} = 0.11, 0.09, 0.07, 0.04$  and  $0.02$  (it meant for all plants produced:  $\text{Frac}_{\text{BURN}} = 0.05, 0.04, 0.03, 0.02$  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 6.4.**

### **6.6.4 QA/QC Information**

See 6.1.5.

### **6.6.5 Source-specific recalculations**

Following the recommendation from the latest centralized review, the notation key 'NA' has been replaced by 'NO' relating to 4.E Prescribed Burning of Savannas in the CRF submission for 2012.

### **6.6.6 Planned improvements**

There are no further improvements planned.

## 6.7 References

Agency for Environmental Protection and Technical Services (APAT, Italy) (2008): Italian Greenhouse Gas inventory 1990-2006. National Inventory Report, 2008, Rome.

Apáti, F. (2003): A magyar rizságazat technológiai és ökonómiai elemzése [Technological and economical analysis of the Hungarian Rice sector]. Debreceni Egyetem Agrár és Műszaki Tudományok Centruma [Centre for Agricultural Science University of Debrecen], Acta-Agraria 2003-10, <http://www.date.hu/acta-agraria/2003-10/apati.pdf> (last version: 20-January-2005) (in Hungarian with English summary)

Babinszky, L. et al. (2002). Magyarország fehérjegyazdálkodásának helyzete és fejlesztési stratégiája [Situation and development strategy of protein management in Hungary]. MTA Agrártudományok Osztálya [Hungarian Academy of Sciences, Division Agricultural Sciences], Budapest. 207 p. (in Hungarian)

Borka, G. (1998): Modelluntersuchungen zur Bestimmung der Ammoniakemissionen aus Rinderexkrementen im Stallbereich. Dissertation ETH Zürich Nr. 12830, 126 p. (in German)

Borka G. (2002): A haszonállat-tartásból származó metánemisszió meghatározására szolgáló differenciált módszer kidolgozása a magyar mezőgazdaság sajátosságainak figyelembe vételével [Elaboration of a differentiated methodology for the determination of the methane emission from livestock keeping, by taking into account the characteristics of the Hungarian agriculture]. Beszámoló jelentés, FVM K+F 120-e/2000 kutatási program [Final report Project FVM K+F 120-e/2000], 16 p. (unpublished, in Hungarian).

Borka G. (2003): Ammónia, nitrogén-oxid és metánemissziók a magyar mezőgazdaságból: emissziós trendek, az emissziócsökkentés lehetőségei, ajánlások [Ammonia, nitrous oxide and methane emissions from the Hungarian agriculture: emission trends, emission reduction options, recommendations]. Beszámoló jelentés, FVM K+F 89-d/2002 kutatási program, 2003. december 20. [statement report FVM K+F 89-d/2002, 20 December, 2003]. 11 p. (unpublished, in Hungarian).

Borka, G. (2007): Az állati termék előállítás hatása az atmoszférára: a nitrogén- és üvegházgázemissziók jelentősége és csökkentési lehetőségei [The effects of animal production on the atmosphere: nitrogen and greenhouse gas emissions and reduction possibilities]. Állattenyésztés és Takarmányozás. 2007. 56:469-487. (in Hungarian with English summary)

Borka, G., Németh, Tímea, Kukovics, S. 2010. Analysis of GHG emissions from sheep sector compared with the features of cattle sector. In: Kukovics, S. – Jávorski, A. (edited) (2010) : Possibilities for development in sheep sector. JUHINNOV PLATFORM, K-OVI-CAP Bt. – University of Debrecen Centre for Agricultural Sciences, Érd-Debrecen, 553 p. (ISBN 978-963-08-0624-4), pp. 315-354, pp. 532-546. (In Hungarian)

Bölcskey, K. senior researcher, Department Cattle Breeding, Institute for Animal Breeding and Nutrition, (2010): Expert judgment, verbal communication

EEA (2007): EMEP/CORINAIR Emission Inventory Guidebook-2007. European Environment Agency. <http://www.eea.europa.eu/publications/EMEPCORINAIR5/page019.html>

Egerszegi, I. senior researcher, Department Reproduction Physiology (Swine), Institute for Animal Breeding and Nutrition, (2010): Expert judgement, verbal communication

FAO (1985-2002). FAO Fertilizer Yearbook, Vol. 35-Vol. 52.

FAO (1985-2002). FAO Production Yearbook, Vol. 39 – Vol. 56.

FAO (2008). FAOSTAT Fertilizers, <http://faostat.fao.org/>

FAO (2008). FAOSTAT Livestock, <http://faostat.fao.org/>

Fébel, H.Ms., Department of Physiology of Nutrition, Research Institute for Animal Breeding and Nutrition (2007). Expert consultation, verbal communication.

Fébel, H.Ms. – Gundel, J.: A takarmányozás és a környezetvédelem kapcsolata. [*Connection between nutrition and environmental protection*]. Állattenyésztés és Takarmányozás. 2007. 56:427-456. (In Hungarian, with English summary)

Gundel, J., scientific adviser, Department of Swine Nutrition, Research Institute for Animal Breeding and Nutrition (2004): Expert judgement, verbal communication.

Györkös, I. scientific adviser, Department Cattle Breeding, Institute for Animal Breeding and Nutrition, (2010): Expert judgement, verbal communication

HCSO [Hungarian Central Statistical Office] (1985-1989, 1997-2005): Statistical Yearbook of Agriculture. Budapest

HCSO [Hungarian Central Statistical Office] (1990-1996): Statistical Pocket-book of Agriculture. Budapest

HCSO [Hungarian Central Statistical Office] (2000a): Agriculture in Hungary, 2000. Regional data. Budapest, 581 p.

HCSO [Hungarian Central Statistical Office] (2000b): Hungarian Agriculture 1851-2000. CD-ROM, Budapest.

HCSO [Hungarian Central Statistical Office] (2001): A mezőgazdaság gép- és épületállománya 1991-2000 [Machinery and building stock of agriculture sector, 1991-2000]. Budapest.

HCSO [Hungarian Central Statistical Office] (2004): Livestock 1851-2003. (internal report)

HCSO [Hungarian Central Statistical Office] (2011a): Mezőgazdaság, 2010. [Agriculture, 2010]. <http://www.ksh.hu/docs/hun/xftp/idoszaki/mezo/mezo10.pdf> ( in Hungarian)

HCSO [Hungarian Central Statistical Office] (2011b): Statat-tables – Times series of annual data 4. Economic sectors. 4.1. Agriculture. <http://portal.ksh.hu/>

HCSO [Hungarian Central Statistical Office] (2010c): Magyarország Mezőgazdasága, 2010 (Általános mezőgazdasági Összeírás), Előzetes adatok. [Agriculture of Hungary, 2010. General Agricultural Census. Provisional data]. <http://portal.ksh.hu/pls/ksh/docs/hun/xftp/idoszaki/gso/gso10.pdf>

IPCC (1996): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

IPCC (2000): Good Practice Guidance and Uncertainty Management in Greenhouse Gas Inventories.

Laczka, É. (2007): A Magyar mezőgazdaság az EU-csatlakozás körüli években, 2000-2005. [Hungarian Agriculture in the years of the European Union Accession, 2000-2005.] Hungarian Statistical Review, Vol. 85. No. 1 pp. 5-20. (In Hungarian, with English summary.) [http://www.ksh.hu/statszemle\\_archive/2007/2007\\_01/2007\\_01\\_001.pdf](http://www.ksh.hu/statszemle_archive/2007/2007_01/2007_01_001.pdf)

Laczka, É. and Soós, L. (2003): Some Characteristics of the Hungarian Agriculture in the 1990s. Hungarian Statistical Review, Special number 8. 2003. pp. 3-19. [http://www.ksh.hu/statszemle\\_archive/2003/2003\\_K8/2003\\_K8\\_003.pdf](http://www.ksh.hu/statszemle_archive/2003/2003_K8/2003_K8_003.pdf)

Magyar Takarmánykódex Bizottság [Hungarian Nutrition Codex Commission] (2004): Magyar Takarmánykódex II. [Hungarian Nutrition Codex II.] 535 p. (in Hungarian)

Mészáros Gy., Ministry of Agriculture and Rural Development (2000): Expert judgement, verbal communication.

Pazsiczki, I., Department for Mechanization of Animal Production, Hungarian Institute of Agricultural Engineering (2005): Expert judgement, verbal communication.

Pazsiczki I., MGI and Borka G., ÁTK (2005): Expert judgement, verbal communication.

Pazsiczki, I.: Trágyatárolás, -kezelés és hasznosítás. [Manure storage, management and utilization]. Állattenyésztés és Takarmányozás. 2007. 56:457-468. (in Hungarian, with English summary)

Ráki, Z. (2003): Az állattartás épületkapacitása, kapacitáskihasználása és a nagyobb telepek műszaki állapota [Building capacity, capacity utilization of animal management and the technical status of larger farms]. Budapest. (unpublished, in Hungarian)

Sári, D. (2003) Expert consultation, verbal communication.

Schmid, M. et al. (2000): Lachgasemissionen aus der Schweizer Landwirtschaft. Schriftenreihe der FAL, 33, 129 p. (in German)

Schmidt, J. et al. (2000): A kérődzők takarmányainak energia- és fehérjeértékelése [Energy and protein assessment of ruminants' food]. Mezőgazda Kiadó, Budapest, 185 p. (in Hungarian)

Systemexpert Tanácsadó Kft. [Systemexpert Consulting LTD] (2007): A 2007-es magyarországi üvegházgáz-leltár IPCC és UNFCCC követelmények szerinti felülvizsgálata és a felhasznált módszertan áttekintése. [Review of the 2007 greenhouse gas inventory of Hungary according to the requirements of the IPPC and UNFCCC and of the applied methodology] Budapest. 27 p. (unpublished, in Hungarian)

Széles Gy.. (szerk.) (1987-1988): Mezőgazdaság számokban. III. Állattenyésztés [Agriculture in numbers. III. Animal breeding]. Agroinform – STAGEK, Budapest. 463 p. (in Hungarian)

Tóth P., HCSO (2004). Expert judgement, verbal communication.

Várhegyi Józsefné et al. (1999). A kérődzők új fehérjeértékelési rendszerének alkalmazása gyakorlati takarmányozásban [Application of the new protein assessment system of ruminants in the practice of feeding]. ÁTK Herceghalom, PATE Mosonmagyaróvár. 68 p.

Várhegyi, Józsefné, Richter J., Chandler P. (2007): WINLP- Feed ration (TMR) mixing for dairy cattle by linear optimization and in conventional manner. Nutrition software for dairy cow, based on Hungarian Nutrition Codex.

Várhegyi J., senior researcher, Department of Ruminant Nutrition, Research Institute for Animal Breeding and Nutrition (2010). Expert judgement, verbal communication.

Walther et al. (1994). Grundlagen für die Düngung im Acker- und Futterbau. FAP Zürich, RAC Nyon, FAC Liebefeld-Bern. Agrarforschung 1 (7), 40 p. (in German)

## 7 Land-Use, Land-Use Change and Forestry (CRF sector 5.)

### 7.1 Overview of sector

#### 7.1.1 Emission trends

The greenhouse gas inventory of the Land Use, Land-Use Change and Forestry (LULUCF) sector comprises emissions and removals of CO<sub>2</sub> due to overall carbon gains or losses in the relevant carbon pools of the predefined six land-use categories. The liming of agricultural lands is included in the LULUCF sector, as well. The non-CO<sub>2</sub> emissions from biomass burning and disturbance associated with land-use conversion to cropland are also to be reported here. These activities altogether resulted in 3,372 Gg net removal of CO<sub>2</sub> equivalent in 2010. The estimated emissions and removals by gases over the period 1985-2010 are presented in Table 7.1.

**Table 7.1. Emissions and removals by gas from LULUCF 1985-2010 (Gg)**

Year	GHG emissions/ removals (Gg)				
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO
BY	-2,209	1.46	0.02	0.29	10.16
1985	-105	1.47	0.02	0.29	10.20
1986	-3,050	1.49	0.02	0.29	10.33
1987	-3,472	1.44	0.03	0.28	9.95
1988	-4,458	1.40	0.03	0.27	9.65
1989	-3,668	1.39	0.04	0.27	9.63
1990	-1,988	1.29	0.05	0.25	8.89
1991	-2,302	1.26	0.05	0.25	8.66
1992	-3,365	1.16	0.05	0.23	7.93
1993	-5,339	1.04	0.05	0.20	7.00
1994	-5,809	1.06	0.06	0.20	7.16
1995	-5,845	1.10	0.07	0.21	7.48
1996	-1,932	1.19	0.08	0.23	8.13
1997	-2,105	1.21	0.08	0.24	8.28
1998	-3,140	1.19	0.09	0.23	8.07
1999	-1,511	1.02	0.10	0.24	8.55
2000	-455	1.48	0.11	0.33	11.45
2001	-1,831	1.33	0.11	0.29	10.35
2002	-1,066	1.31	0.11	0.30	10.41
2003	-3,259	1.27	0.11	0.29	10.27
2004	-2,347	1.10	0.11	0.25	8.89
2005	-4,485	1.71	0.12	0.40	14.16
2006	-2,379	1.02	0.11	0.25	8.93
2007	-2,748	1.51	0.11	0.36	12.74
2008	-4,258	1.12	0.10	0.25	8.90
2009	-3,370	1.11	0.10	0.25	8.76
2010	-3,423	1.10	0.09	0.26	9.18
<b>Trend BY-2010 (%)</b>	<b>62</b>	<b>-25</b>	<b>301</b>	<b>-10</b>	<b>-10</b>

The LULUCF sector was a net sink of CO<sub>2</sub> in Hungary in all years from 1985 to 2010. Forest



Land is a net carbon sink, whereas Settlements are net source of greenhouse gases, Grassland and Cropland are net sources in some years and a net sinks in other years.

In 2010, removals from LULUCF corresponded to 5.0 per cent of total GHG emissions in Hungary (excluding LULUCF), compared to its 1.9% share in the base year. The variability of removals from LULUCF was rather high over the period 1985-2010, as shown in Table 7.2.

**Table 7.2. Trends in CO<sub>2</sub>-eq emissions/removals from LULUCF by land-uses 1985-2010**

Year	GHG emissions/ removal Gg CO <sub>2</sub> -eq				
	5.	5.A	5.B	5.C	5.E
BY	-2,171	-2,766	367	144	84
1985	-68	-1,186	768	261	88
1986	-3,012	-3,344	70	180	82
1987	-3,433	-3,769	263	-10	83
1988	-4,418	-4,018	-467	-10	77
1989	-3,626	-2,721	-975	-4	75
1990	-1,947	-2,401	306	33	115
1991	-2,261	-2,733	124	264	84
1992	-3,327	-3,435	-207	246	68
1993	-5,301	-5,147	-664	408	101
1994	-5,769	-5,673	-658	471	92
1995	-5,801	-5,710	-705	508	106
1996	-1,884	-1,802	-710	528	99
1997	-2,054	-2,067	-665	567	110
1998	-3,087	-3,054	-718	568	116
1999	-1,460	-1,398	-755	574	120
2000	-391	-378	-707	486	208
2001	-1,770	-1,902	-556	486	202
2002	-1,004	-1,379	-376	524	228
2003	-3,198	-3,514	-435	510	241
2004	-2,289	-2,544	-526	506	276
2005	-4,413	-4,673	-460	504	216
2006	-2,324	-2,654	-437	524	243
2007	-2,683	-2,910	-501	520	208
2008	-4,203	-4,073	-802	474	199
2009	-3,316	-3,145	-875	479	225
2010	-3,372	-3,094	-922	445	199
<b>Share in Hungarian total in BY</b>	1.9%	2.4%	0.3%	0.13%	0.07%
<b>Share in Hungarian total in 2010</b>	5.0%	4.6%	1.4%	0.7%	0.3%
<b>Trend BY-2010</b>	55%	12%	-351%	209%	136%

The most important sub-category as the main source of removal in the sector is 5.A Forest Land. The bulk of the CO<sub>2</sub> removal is generated in living biomass in 5.A.1 Forest Land remaining Forest Land category. The large sink is mainly due to the fact that the total increment of the growing stock in forest lands is always higher than the annual harvest. The total net emissions/removals from the other land-use categories is less than 3% of the national total in 2010.

Although the reported emissions/removals from 5.B Cropland, 5.C Grassland and 5.E Settlements are insignificant, but their trends are significant, particularly for Grassland as shown in Table 7.2. The long-term growth in the emissions from Grassland is determined principally by the change in the grassland management as a result of the drop of grazing animal livestock after the change of the regime at the beginning of the nineties (for more

details see Chapter 6.1 and Chapter 7.5). It is also to be noted that trends in the emissions from Grassland and Settlements are exaggerated due to the impact of the 20-year rolling period starting in 1985. In accordance with the GPG for LULUCF (IPCC, 2000), a unit of land subject to a change of use remains in the conversions sub-category for 20 years before it is reported in the remaining sub-category of the new land-use category to which it has been converted. The land-use conversions have been taken into account since 1985 for Hungary, which results a slightly decreasing, and significantly increasing trends in the area of the 'remaining' and the 'converted to' sub-categories of the different land-uses, respectively. The increasing trends in the area of the conversion categories over the period 1985-2005 resulted in exaggerated increasing trends in the emissions from Settlements and Grassland. In the case of Forest Land this saturation problem does not influence the trend in the emissions/removals. The trend in emissions from Cropland only partly reflects this problem as a result of different compensatory processes in the emissions and removals within the sub-sector.

It should be noted that the land-use conversions that have been taken into account since 1985 have no influence on the trends after 2005. On the other hand emissions from the 5.B, 5.C and 5.E are small and their effect on overall trend in national total is negligible.

The net increase in carbon stock in living biomass in the category 5.A Forest Land was 850 Gg C in 2010. The living biomass in Cropland was a net sink of 11 Gg C. It should be noted that the reported carbon stock change in living biomass in the category 5.B.1 Cropland in this submission cannot be compared to the estimates reported in the previous submissions, because of the methodological change (see also Chapter 7.4.2, and Chapter 7.12). Mineral soils in croplands were a sink of 250 Gg C as a result of the abandonment of 583,3 kha cropland and the soil conservation tillage practices. Grassland was a source of 444 Gg CO<sub>2</sub> due to the continuously decreasing area of improved grasslands. While the total area of Grassland is slightly decreasing, the area of Settlements is increasing, which resulted in an emission of 199 Gg CO<sub>2</sub> in 2010. Liming in agricultural soils contributed 6.9 Gg CO<sub>2</sub> to the emissions in 2010. In addition, the non-CO<sub>2</sub> emissions from biomass burning were 1.10 Gg CH<sub>4</sub> and 0.01 Gg N<sub>2</sub>O. In this category the controlled burning of slash in Forest Land and the wildfires in Forest Land, Cropland and Grassland are reported. The other source of N<sub>2</sub>O emissions is the disturbance associated with land-use conversion to cropland, which amounted to 0.08 Gg N<sub>2</sub>O in 2010.

### **7.1.2 Key categories**

Key category analysis is presented in Chapter 1.6. Table 1.2 contains the key categories of the LULUCF sector.

### **7.1.3 Completeness**

In submission 2012 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 Settlements (CRF 5.E). In category 5.A Forest Land carbon stock change in living biomass and dead organic matter are reported. In categories 5.B Cropland, 5.C Grassland and 5.E Settlements carbon stock changes in living biomass, dead organic matter and mineral soils are reported. N<sub>2</sub>O emissions from fertilization (CRF 5(I)) are reported under the Agriculture sector (CRF 4). N<sub>2</sub>O emission from soil disturbance associated with land-use conversion to cropland is also to be reported in CRF table 5(III). In addition, CO<sub>2</sub> emission from liming is reported in CRF table 5(IV) and CO, CH<sub>4</sub>, N<sub>2</sub>O and NO<sub>x</sub> 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 Other Land (CRF 5F). In these categories only area data are reported. Other Land is unmanaged; therefore emissions from this category are not reported. Non-CO<sub>2</sub> emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported as drainage is a very rare activity in Hungary. Emissions from organic soils are not reported either because organic

soils are not in use for agricultural purposes.

The number of categories reported using notation keys has been reduced for this submission as an outcome of the centralized review of our 2011 submission. To improve transparency, the following changes were made:

- Removals/emissions from 5.A.2. Land converted to Forest Land have been reported separately, by former land-use categories. (Previously all emissions/removals from 5.A.2 were reported altogether in the category 5.A.2.1 and notation key 'IE' were used for the other land-use categories.)
- The area and related emissions and removals from Forest Land and Grassland converted to Other land-use categories have been calculated and reported in the 'Information items' in the CRF table 5. (Previously notation key 'NE' was reported.)

NIR chapters have been supplemented with additional information on categories reported using notation key 'NE' (justification for omitting emissions and removals) to improve transparency.

The coverage of the LULUCF sector is presented in Table 7.3.

**Table 7.3. Completeness of LULUCF sector**

GHG source and sink categories	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
5.A. Forest Land			
1. Forest Land remaining Forest Land	R	R	R
2. Land converted to Forest Land	R	NO	NO
5.B Cropland			
1. Cropland remaining Cropland	R	R	R
2. Land converted to Cropland	R	IE, NO	R
5.C Grassland			
1. Grassland remaining Grassland	R	R	R
2. Land converted to Grassland	R	IE, NO	IE, NO
5.D Wetlands			
1. Wetlands remaining Wetlands	NE <sup>1</sup> , NO	NO	NO
2. Land converted to Wetlands	NE, NO	NE, NO	NE, NO
5.E Settlements			
1. Settlements remaining Settlements	NE <sup>2</sup>	NA	NA
2. Land converted to Settlements	R	NA	NA
5.F Other Land			
1. Other Land remaining Other Land			
2. Land converted to Other Land	NE <sup>3</sup>	NA	NA
5(I) Direct N <sub>2</sub> O emissions from N fertilization			NO
5(II) Non-CO <sub>2</sub> emissions from drainage of soils and Wetlands		NE, NO	NE, NO
5(III) N <sub>2</sub> O emissions from disturbance associated with land-use conversions to cropland			R
5(IV) CO <sub>2</sub> emissions from agricultural lime application	R		
5(V) Biomass burning	IE, NA, NO	R	R

Legend: R=reported

<sup>1,2</sup>Parties may decide not to prepare estimates for these categories.

<sup>3</sup>Other Land is considered unmanaged, therefore not reported.

#### 7.1.4 Methodology

The IPCC Tier 2 methodology (i.e. country-specific wood-density), provided by the GPG for LULUCF (IPCC, 2003) is used for the estimation of emissions/removals from living biomass

of Forest Land, while Tier 1 methodology is used in the case of other pools and land-use categories.

For representing land areas a mix of the IPCC Approach 1 and 2 methods is used. The National Forest Inventory provides activity data for the forest land, which are suitable for using higher Approaches, but in case of the other land-uses the most reliable dataset can be achieved by combining the Approach 1 land-use statistics with land-cover change databases. The foregoing chapter summarizes the main information about the land area representation as well as the activity data of the estimations and the emission factors used.

## 7.2 Land area representation used in the Hungarian Inventory

The key activity data to provide emission estimation for land-use changes are the land areas according to the consistent area representation recommended by the GPG (IPCC, 2003). This chapter presents a description of data sources of the land area representation, the national application of the IPCC land-use categories and the resulted land-use change matrices. (For the detailed methodological description on the compilation of land-use change matrices see Annex A3.4.)

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 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 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 referring to 1990, 2000 and 2006 (CLC90, CLC2000 and CLC2006, respectively) and the CORINE Land Cover-change databases referring to 1990-2000 and 2000-2006 (CLC-changes<sub>1990-2000</sub>, CLC-changes<sub>2000-2006</sub>) as well as the results of satellite image processing implemented for GHG inventory purposes for 1985 and 1985-1990 (HLC85 and HLC-Changes<sub>1985-1990</sub> databases).

The forest inventory (based on which the National Forestry Database, NFD is maintained) provides the data for our estimates for Forest land. NFD comprises data on the whole forested area of the country regardless of ownership. The survey is continuous; approximately 10 percent of the whole forested area is renewed annually, and the whole forested area is thus 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 1 January 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](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, which are as follows: Arable land, Kitchen garden, Orchard, Vineyard, Grassland, Forest, Reed, Fishpond, Uncultivated land area. The data refer to those areas that are declared to be 'in use' under the specified nine land-use categories by agricultural enterprises and private farms. Lands not in use for agricultural purposes are reported aggregately as uncultivated land area. The data acquisition is based on questionnaires, and land-use data are available since 1853, although there have been changes in the methodology since the beginning of the data collection (Kecskés, 1997). To ensure consistency, the data set was adjusted according to the methodological changes. (It is important to note, that the Forest

area reported by the HCSO differs from the CAO, Forestry Directorate data because of differences in data collection and the Forest area definition. Forest areas reported by the HCSO are not used for GHG inventory purposes. The HCSO's data refer to the areas of land that are 'in use' therefore areas that not covered by trees are not reported as forests in this statistics.)

The HCSO's land-use statistics is the unique unified land-use data set for Hungary for the whole inventory time series. It represents the whole area of the country but as its background is an agricultural survey, it does not contain information on Settlements, and Wetlands. (However, Fishponds and Reeds are reported in it, but these categories represent 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 CLC, HLC, CLC-change, and HLC-change databases. The annual data were interpolated from these databases.

The HCSO's land-use statistics do not contain information on land-use changes, only the net area data for the different categories are available. Unified data set for land-use changes for the whole inventory period was not available, but the HLC-changes<sub>1985-1990</sub>, CLC-changes<sub>1990-2000</sub>, CLC-changes<sub>2000-2006</sub> datasets contain information on the land-cover changes for the all IPCC categories. Nevertheless, the difference between the 'land-use' and 'land-cover' can cause some discrepancies. The two CLC-change databases were supplemented by a third, auxiliary land-cover change database for the years of 1985-1990 (HLC-Changes<sub>1985-1990</sub>). This data set is similar to the other CLC-change datasets 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 (FÖMI, 2009b). It is important to note that the minimal extension of the mapped area is 25 ha in the CLC and HLC databases, but 5 ha in the CLC-change and HLC-change databases. (FÖMI, 2004; FÖMI, 2009a; FÖMI 2009b)

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. Land cover databases

### ***7.2.1 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 were 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<sup>3</sup>, 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

---

<sup>3</sup> In Hungarian terms kitchen garden means vegetable garden.

crops are included. Area of kitchen gardens utilized 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<sup>2</sup> or above in case of berries and 400 m<sup>2</sup> 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<sup>2</sup> in area.

Cropland category contains the set-aside Croplands as well. The annual area of set-aside croplands were estimated from the compilation of the HCSO land-use statistics and the CLC-change databases.

#### Grassland

Grassland area refers to the Grassland (meadow and pasture) area which is reported in the "Land area of Hungary by land use categories" statistics of HCSO. Land area utilized as meadow or pasture is reported here.

Meadow: land area under grass (artificial planting included), and the production is utilized by cutting, irrespective of whether it is used for grazing sometimes.

Pasture: land area under grass (artificial planting included) utilized for grazing irrespective of whether it is used for cutting sometimes. Land areas under grass with trees utilized for grazing are included.

It should be noted; that this category contains the natural grasslands (set-aside grasslands) which are not in use for agricultural purposes. The annual area of set-aside grasslands were estimated from the compilation of the HCSO land-use statistics and the CLC-change databases.

#### Wetlands

Wetland area matches with 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. Peat extraction is negligible in Hungary.)

#### Settlements

This category matches with 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

This category matches with the 'Open spaces with little or no vegetation' category of the CORINE land-cover database, which comprises the sparsely vegetated areas, which includes even less vegetation, than the natural grassland category.

Table 7.4 shows the land-use changes over the period 1985 to 2010 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 was taken into account in the calculation of the areas of the remaining and converted to categories. In the Forest Land category the transition period depends on tree species, therefore data of the Land converted to Forest Land categories in the next table differ from those that are reported in the CRF Table 5.A.2 Land converted to Forest Land. The next matrices provided activity data for the estimation of emission from carbon stock change in mineral soils in Cropland, Grassland and Settlements categories. For the estimation of carbon stock change in living biomass, the annual conversions were taken into account instead of areas calculated using the 20-year transition period. Details of implementation of land-use change matrices are reported in Annex A3-4.



**Table 7.4. Land use matrices 1985-2010 (ha)**

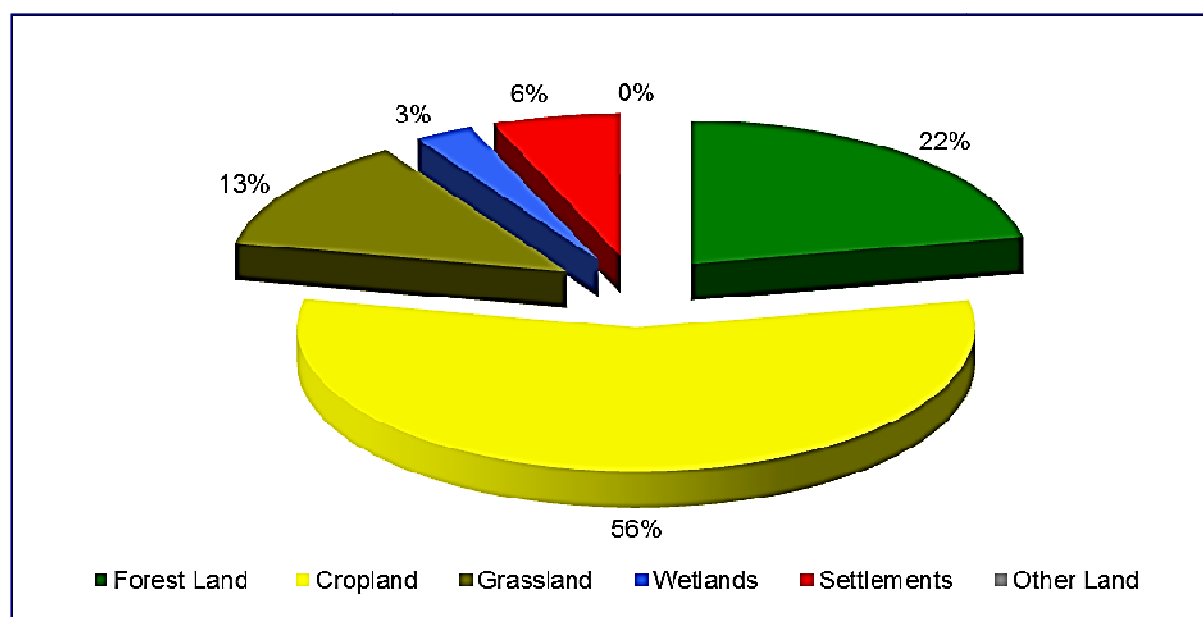
	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Forest Land	1,740,962	95	21	0	210	0
Cropland	11,166	5,474,905	5,338	0	838	0
Grassland	3,379	4,910	1,280,922	298	391	0
Wetlands	16	0	0	251,745	14	0
Settlements	118	9	117	23	525,344	0
Other Land	0	0	0	0	0	2,444
<b>1985</b>	<b>1,755,640</b>	<b>5,479,919</b>	<b>1,286,397</b>	<b>252,067</b>	<b>526,798</b>	<b>2,444</b>
Forest Land	1,740,636	190	42	0	421	0
Cropland	19,168	5,460,727	10,675	0	1,677	0
Grassland	5,800	9,821	1,272,901	596	782	0
Wetlands	27	0	0	251,720	29	0
Settlements	202	19	235	47	525,109	0
Other Land	0	0	0	0	0	2,444
<b>1986</b>	<b>1,765,833</b>	<b>5,470,756</b>	<b>1,283,852</b>	<b>252,363</b>	<b>528,018</b>	<b>2,444</b>
Forest Land	1,740,309	284	63	0	631	0
Cropland	27,676	5,451,380	10,675	0	2,515	0
Grassland	8,375	17,186	1,262,271	894	1,173	0
Wetlands	38	0	0	251,694	43	0
Settlements	292	28	352	70	524,869	0
Other Land	0	0	0	0	0	2,444
<b>1987</b>	<b>1,776,691</b>	<b>5,468,879</b>	<b>1,273,361</b>	<b>252,658</b>	<b>529,232</b>	<b>2,444</b>
Forest Land	1,739,983	379	83	0	842	0
Cropland	36,228	5,441,989	10,675	0	3,354	0
Grassland	10,963	24,552	1,251,629	1,192	1,564	0
Wetlands	50	0	0	251,668	57	0
Settlements	382	38	470	94	524,628	0
Other Land	0	0	0	0	0	2,444
<b>1988</b>	<b>1,787,607</b>	<b>5,466,958</b>	<b>1,262,857</b>	<b>252,954</b>	<b>530,446</b>	<b>2,444</b>
Forest Land	1,739,657	474	104	0	1,052	0
Cropland	46,995	5,430,384	10,675	0	4,192	0
Grassland	14,221	31,918	1,240,316	1,490	1,956	0
Wetlands	65	0	0	251,638	72	0
Settlements	496	47	587	117	524,364	0
Other Land	0	0	0	0	0	2,444
<b>1989</b>	<b>1,801,435</b>	<b>5,462,823</b>	<b>1,251,682</b>	<b>253,246</b>	<b>531,636</b>	<b>2,444</b>
Forest Land	1,739,044	654	145	0	1,445	0
Cropland	56,945	5,419,595	10,675	0	5,031	0
Grassland	17,232	39,283	1,229,250	1,788	2,347	0
Wetlands	79	0	0	251,610	86	0
Settlements	601	57	704	141	524,109	0
Other Land	0	0	0	0	0	2,444
<b>1990</b>	<b>1,813,902</b>	<b>5,459,589</b>	<b>1,240,774</b>	<b>253,539</b>	<b>533,017</b>	<b>2,444</b>
Forest Land	1,738,805	714	158	0	1,612	0
Cropland	65,877	5,393,812	26,688	0	5,869	0
Grassland	19,935	39,283	1,225,858	2,086	2,738	0

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Wetlands	92	0	0	251,583	100	0
Settlements	696	66	822	164	523,864	0
Other Land	0	0	0	0	0	2,444
1991	1,825,404	5,433,875	1,253,526	253,834	534,184	2,444
Forest Land	1,738,679	758	167	0	1,684	0
Cropland	75,813	5,367,024	42,701	0	6,708	0
Grassland	22,941	39,283	1,222,162	2,384	3,129	0
Wetlands	105	0	0	251,555	114	0
Settlements	800	76	939	188	523,609	0
Other Land	0	0	0	0	0	2,444
1992	1,838,339	5,407,141	1,265,970	254,127	535,244	2,444
Forest Land	1,738,350	771	250	0	1,917	0
Cropland	82,518	5,352,674	49,409	0	7,646	0
Grassland	24,303	47,552	1,211,637	2,981	3,426	1
Wetlands	123	0	0	251,529	123	0
Settlements	1,044	104	1,117	204	523,143	0
Other Land	0	0	0	0	0	2,444
1993	1,846,338	5,401,101	1,262,412	254,714	536,255	2,445
Forest Land	1,738,132	799	277	0	2,080	0
Cropland	87,366	5,340,182	56,116	0	8,583	0
Grassland	25,287	55,821	1,201,489	3,578	3,724	2
Wetlands	136	0	0	251,508	131	0
Settlements	1,220	132	1,295	220	522,745	0
Other Land	0	0	0	0	0	2,444
1994	1,852,141	5,396,934	1,259,176	255,305	537,263	2,446
Forest Land	1,737,774	852	337	0	2,324	0
Cropland	95,125	5,324,777	62,824	0	9,521	0
Grassland	26,862	64,090	1,190,749	4,175	4,021	2
Wetlands	157	0	0	251,479	139	0
Settlements	1,502	160	1,472	236	522,242	0
Other Land	0	0	0	0	0	2,444
1995	1,861,421	5,389,880	1,255,383	255,889	538,247	2,447
Forest Land	1,737,428	931	416	0	2,512	0
Cropland	103,716	5,308,541	69,531	0	10,458	0
Grassland	28,607	72,359	1,179,841	4,771	4,319	3
Wetlands	180	0	0	251,447	147	0
Settlements	1,814	188	1,650	252	521,708	0
Other Land	0	0	0	0	0	2,444
1996	1,871,746	5,382,020	1,251,438	256,471	539,144	2,447
Forest Land	1,736,906	1,123	507	0	2,751	0
Cropland	113,656	5,290,957	76,238	0	11,396	0
Grassland	30,625	80,628	1,168,659	5,368	4,616	4
Wetlands	207	0	0	251,413	156	0
Settlements	2,175	216	1,827	268	521,125	0
Other Land	0	0	0	0	0	2,444
1997	1,883,569	5,372,924	1,247,232	257,049	540,044	2,448

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Forest Land	1,736,504	1,212	548	0	3,023	0
Cropland	122,347	5,274,621	82,946	0	12,333	0
Grassland	32,390	88,897	1,157,731	5,965	4,913	5
Wetlands	230	0	0	251,381	164	0
Settlements	2,491	245	2,005	284	520,587	0
Other Land	0	0	0	0	0	2,444
1998	1,893,962	5,364,974	1,243,230	257,630	541,021	2,449
Forest Land	1,736,109	1,239	639	0	3,301	0
Cropland	133,575	5,255,748	89,653	0	13,271	0
Grassland	34,669	97,165	1,146,287	6,562	5,211	6
Wetlands	260	0	0	251,343	172	0
Settlements	2,899	273	2,183	300	519,958	0
Other Land	0	0	0	0	0	2,444
1999	1,907,512	5,354,425	1,238,762	258,204	541,912	2,450
Forest Land	1,735,390	1,307	696	0	3,896	0
Cropland	145,149	5,236,528	96,361	0	14,209	0
Grassland	37,019	105,434	1,134,773	7,159	5,508	6
Wetlands	291	0	0	251,303	180	0
Settlements	3,320	301	2,360	316	519,315	0
Other Land	0	0	0	0	0	2,444
2000	1,921,170	5,343,570	1,234,189	258,778	543,108	2,451
Forest Land	1,734,869	1,368	796	0	4,254	0
Cropland	158,779	5,219,086	98,208	0	16,174	0
Grassland	39,498	108,419	1,128,284	7,646	6,047	6
Wetlands	302	0	0	251,258	216	0
Settlements	3,496	302	2,479	346	518,988	0
Other Land	0	0	0	0	0	2,444
2001	1,936,944	5,329,175	1,229,768	259,249	545,679	2,451
Forest Land	1,734,232	1,477	886	0	4,694	0
Cropland	174,565	5,199,488	100,056	0	18,139	0
Grassland	42,370	111,404	1,121,403	8,133	6,585	6
Wetlands	313	0	0	251,211	251	0
Settlements	3,701	304	2,598	376	518,634	0
Other Land	0	0	0	0	0	2,444
2002	1,955,180	5,312,672	1,224,942	259,719	548,302	2,451
Forest Land	1,733,638	1,503	930	0	5,217	0
Cropland	185,427	5,184,814	101,903	0	20,103	0
Grassland	44,345	114,388	1,115,417	8,620	7,123	6
Wetlands	321	0	0	251,167	287	0
Settlements	3,842	305	2,717	406	518,343	0
Other Land	0	0	0	0	0	2,444
2003	1,967,573	5,301,010	1,220,967	260,192	551,073	2,451
Forest Land	1,732,694	1,577	1,049	0	5,968	0
Cropland	197,364	5,169,064	103,751	0	22,068	0
Grassland	46,516	117,373	1,109,236	9,107	7,661	6
Wetlands	330	0	0	251,123	322	0

	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land
Settlements	3,997	306	2,836	435	518,038	0
Other Land	0	0	0	0	0	2,444
<b>2004</b>	<b>1,980,902</b>	<b>5,288,320</b>	<b>1,216,871</b>	<b>260,665</b>	<b>554,057</b>	<b>2,451</b>
Forest Land	1,746,962	1,553	1,055	0	6,070	0
Cropland	188,531	5,167,933	100,260	0	23,195	0
Grassland	43,562	115,447	1,110,278	9,296	7,808	6
Wetlands	316	0	0	251,407	343	0
Settlements	3,909	298	2,837	442	519,312	0
Other Land	0	0	0	0	0	2,444
<b>2005</b>	<b>1,983,280</b>	<b>5,285,232</b>	<b>1,214,430</b>	<b>261,145</b>	<b>556,729</b>	<b>2,451</b>
Forest Land	1,756,972	1,503	1,055	0	6,303	0
Cropland	193,662	5,156,003	96,770	0	24,321	0
Grassland	43,529	113,522	1,109,355	9,485	7,955	6
Wetlands	315	0	0	251,683	364	0
Settlements	3,995	290	2,838	448	520,446	0
Other Land	0	0	0	0	0	2,444
<b>2006</b>	<b>1,998,472</b>	<b>5,271,318</b>	<b>1,210,018</b>	<b>261,616</b>	<b>559,391</b>	<b>2,451</b>
Forest Land	1,767,911	1,425	1,070	0	6,285	0
Cropland	205,187	5,139,627	98,618	0	25,448	0
Grassland	41,888	109,141	1,104,550	9,674	8,102	6
Wetlands	303	0	0	251,969	386	0
Settlements	3,905	282	2,840	455	521,751	0
Other Land	0	0	0	0	0	2,444
<b>2007</b>	<b>2,019,194</b>	<b>5,250,474</b>	<b>1,207,078</b>	<b>262,098</b>	<b>561,972</b>	<b>2,451</b>
Forest Land	1,778,859	1,428	1,085	0	6,235	0
Cropland	207,662	5,132,258	100,465	0	26,574	0
Grassland	39,943	104,760	1,100,036	9,863	8,250	6
Wetlands	291	0	0	252,255	407	0
Settlements	4,075	274	2,841	461	522,795	0
Other Land	0	0	0	0	0	2,444
<b>2008</b>	<b>2,030,830</b>	<b>5,238,720</b>	<b>1,204,427</b>	<b>262,579</b>	<b>564,260</b>	<b>2,451</b>
Forest Land	1,792,557	1,390	1,167	0	6,320	0
Cropland	204,998	5,127,812	102,312	0	27,701	0
Grassland	37,380	100,379	1,095,468	10,052	8,397	6
Wetlands	276	0	0	252,542	428	0
Settlements	4,134	266	2,843	468	523,926	0
Other Land	0	0	0	0	0	2,444
<b>2009</b>	<b>2,039,347</b>	<b>5,229,846</b>	<b>1,201,790</b>	<b>263,061</b>	<b>566,771</b>	<b>2,451</b>
Forest Land	1,805,429	1,269	1,173	0	6,030	0
Cropland	201,340	5,125,262	104,160	0	28,827	0
Grassland	34,742	95,998	1,091,244	10,241	8,544	6
Wetlands	263	0	0	252,828	449	0
Settlements	4,621	258	2,844	474	524,820	0
Other Land	0	0	0	0	0	2,444
<b>2010</b>	<b>2,046,394</b>	<b>5,222,788</b>	<b>1,199,421</b>	<b>263,542</b>	<b>568,670</b>	<b>2,451</b>

Figure 7.1 shows the distribution of the net areas of the six, broad IPCC land-use categories in Hungary in 2010. Cropland is the dominant land-use category in all years, accounting for 56 per cent of the total area of Hungary in 2010, followed by the Forest Land accounting for 22 per cent. Grassland is the next largest at 13 per cent, followed by Settlements category at 6 per cent, the next one is the Wetlands category at 3 per cent and the smallest one is the Other Land at 0.03 per cent of the total. The major land-use changes since 1985 have been the abandonment of Croplands and Grasslands and the afforestation of abandoned Croplands. 713 thousand hectares Cropland and 483 thousand hectares Grassland were abandoned, and the Forest Land area increased by 291 thousands hectares over the period from 1985-2010.



**Figure 7.1.** Distribution of IPCC land-use categories in Hungary in 2010

Note: Proportion of the Other Land is 0.03%.

### 7.2.2 Emission factors

In the estimations for Forest Land, country-specific factors were used wherever possible, and the IPCC default ones in a few cases. For the other land-use categories the IPCC default emission factors provided by the GPG (IPCC, 2003) were used, except Settlements where the default emission factor from the 2006 IPCC Guidelines (IPCC, 2006) was applied.

### 7.3 Forest Land (CRF sector 5.A)

A general description of the Hungarian forests and forestry in English can be found at [http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT).

A detailed description of forestry-related databases of CAO FD (Central Agricultural Office, Forestry Directorate) in English at [http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/forest-db.html](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/forest-db.html)

Further data and information, mainly in Hungarian, can also be found on the website of the CAO at [http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag](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.

Forest land covers 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 2,046.4 thousand ha by the end of 2010. Note that, before 2009 we only reported the stocked area (see below), however, beginning with 2010, we report the total land under forest management as forest land, and this area is reported in the land-use change matrix.

The total area of all forest subcompartments (i.e. the potentially stocked area) amounted to 1,922.1 thousand ha. The area actually covered by trees (i.e. the actually stocked area), which appears in several official Hungarian statistics, amounted to 1,862.0 thousand ha. This area is calculated from that of the forest subcompartments by adjusting for gaps and overlaps in the canopy closure.

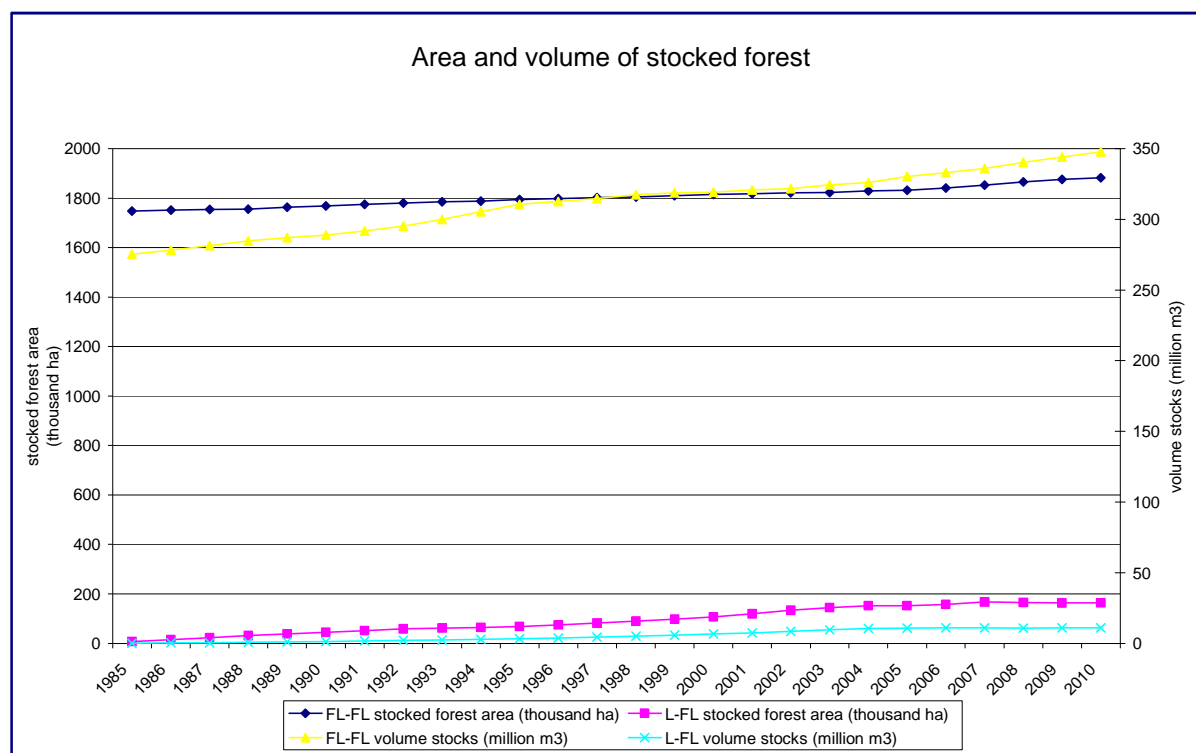
As mentioned above, the total forest area is reported both in the graphs in this report and in the CRF tables, however, the carbon stock changes actually take place in the forest compartments, thus, the implied emission factor and m<sup>3</sup> per ha data should reflect the area of forest sub-compartments.

**Table 7.5.** *The area of forest land, forest compartments and land covered by trees (ha) over time*

Reporting year	Total forest area (forest subcompartments and other)	Area of forest subcompartments	Calculated area covered by trees
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

Reporting year	Total forest area (forest subcompartments and other)	Area of forest subcompartments	Calculated area covered by trees
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
2009	2,039,347	1,912,917	1,853,170
2010	2,046,394	1,922,108	1,862,002

Of all the forests, more than 700 thousand ha were established since 1930. After periods of slow increase of the forest area, afforestations have been recently intensified (Figure 7.2.) Forest management has a long history in the country, too, and most forests are more or less intensively managed. Finally, there are no unmanaged forests in the country. There are some forests where no forestry operations have taken place for about two decades to a century though. These are called forest reserves, however, they only occupy a few thousand ha, i.e. 0.5% of all forests, and even these forests are managed in one way or another: forest monitoring, inspecting, forest protection, forest tourism and game management may take place even in these forests. Therefore, all reported forests of Hungary are considered as managed.



**Figure 7.2.** 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 rather small, but not zero, and have been recalculated in the 2012 submission (see text below)



Forest management planning as well as forest inspection is 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 dendrological 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. The forest inventory statistics include, and have always included, all losses of volume stocks due to all deforestations. *Carbon stock changes due to deforestations are thus reported separately in this inventory.*

For this report, the Forest Directorates (i.e. operation units of the forest authority) estimated and reported the annual amount of both deforestations and afforestations within the limits of their operation, and these estimates were totalled to get an estimate for the entire country. On an area basis, deforestation is rather small, its area being under 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. The mean annual rate of afforestations, i.e. land conversion to forest, amounts to some 9 kha annually. The reason for these area dynamics is that the Hungarian Forest Law is really rather rigorous and is also rather strictly implemented with respect to the deforestations, whereas afforestations are needed to increase forest resources, which are less than e.g. the average of the EU. Also, forest owners who make a deforestation are obliged to cover the costs of a new afforestation of the same area to offset that deforestation, and these costs are always used to make the afforestation elsewhere.

**Table 7.6.** *The area of, and emissions from, deforestations. The area has been slightly fluctuating because of varying rate of highway building of the last few years, but constantly very low*

Inventory year	Conversions from FL to other land use	
	Area (ha)	CO <sub>2</sub> emissions from biomass (Gg)
1985	326.1	41.0
1986	326.1	41.0
1987	326.1	41.0
1988	326.1	41.0
1989	326.1	41.0
1990	612.9	77.1
1991	239.8	30.1
1992	125.6	15.8
1993	328.6	41.2
1994	218.2	27.4
1995	357.8	44.8
1996	345.9	43.3
1997	522.0	65.6

Inventory year	Conversions from FL to other land use	
	Area (ha)	CO <sub>2</sub> emissions from biomass (Gg)
1998	402.0	50.2
1999	395.4	49.4
2000	719.1	89.7
2001	520.9	64.9
2002	637.5	79.4
2003	593.3	73.9
2004	943.8	117.4
2005	411.1	51.1
2006	508.6	63.2
2007	245.5	30.5
2008	293.8	27.1
2009	455.0	58.0
2010	208.3	27.8

We note that, in general, we used the IPCC 2006 Guidelines as a methodological basis for the development of the GHG inventory. We selected these 2006 Guidelines over the GPG (IPCC 2003) because the 2006 Guidelines are clearer with respect to the description of the methodology, contain more and updated default values and are based on updated scientific basis, while being basically consistent with the GPG. Also, the 2006 Guidelines in theory provide more flexibility with respect to accounting for land in the Land converted to Forest Land category because they allow for a transition period of less than 20 years, and this option is consistent with our land statistics by which we used to easily and practicably separate areas in this category from areas in the Forest Land remaining Forest Land (FL-FL) category until 2011. Beginning with the 2012 submission, after having made necessary developments in the database system, we will be using the default transition period of 20 years to populate the Land converted to Forest Land (L-FL) category.

Finally, the IPCC 1996 Revised Guidelines are also used to obtain estimates for emissions related to fires.

In general, we apply Tier 2 methodology with country specific data where we have any. We also apply “best estimates”, i.e. we have made use of all data that exist within the country in relation to the GHG inventory.

With respect to data sources, the activity data was taken from the *National Forest Database and related forestry databases*. These databases contain 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).

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 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 areas covered by trees, as well as roads and other areas that are under forest management but that are not covered by trees (see *Table 7.5*).

*“Afforestations”* or *“reforestations”* are activities that lead to conversion of non-forest land to forest land. From a domestic administrative point of view, the conversion can take place in a period of 3-15 years, depending on tree species and site, but, as mentioned above, since 2012 we have used the default transition period of 20 years to account for emissions and removals in the L-FL category.

*“Deforestation”* is a conversion of forest land to non-forest land, which takes place within one year. (This also means that we account for all emissions due to deforestation in the year of the deforestation itself.)

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

*“Below-ground biomass”* is the total biomass of the above trees minus their above-ground biomass.

We also note here that, in this GHG inventory, annual changes in both the area and the annual emissions and removals in the Forest Land category are classified into four groups of subcategories. This is one more than the three ones that can be defined by the various IPCC guidelines, which are the following: Forest Land remaining Forest Land (FL-FL), land converted to FL subcategory (L-FL; the conversions being afforestations and reforestations), and FL converted to other land uses (the conversions being deforestations). The introduction of the fourth group is necessary in our case in order to comply with the guidance of the 2006 Guidelines which says (section 4.2.1.1) that “Subsequent inventories must also allow identical area coverage in order to get reliable results when using the stock-difference method”.

In principle, all changes of the area of the FL-FL subcategory are due to afforestations/reforestations and deforestations. In Hungary, however, areas of these conversions in total are less than the changes between the total forest areas between two consecutive years that are assessed using the data in our databases. In other words, the forest inventory each year identifies (“finds”) forest areas that are additional to the net changes of afforestations/reforestations and deforestations. The area of these “found forests” (FF) is relatively large, i.e. on average about half of annual afforestations (Figure 11.1).

From a statistical and database point of view, only those areas can be regarded as “forest” in any inventory year that the forest inventory system “knows” that they exist. It must be underlined here that the forest inventory system in Hungary, just like that in most other countries, was designed and run in the last several decades in order to capture the (entire) *area* that is deemed to be forest according to laws and regulations in effect at the time, and not to capture *changes* of this area. Any changes were only registered as a result of different *mechanisms* that were *required by domestic law*, such as subsidizing afforestations, or inspecting the implementation of the Forest Act in effect, i.e. closely monitoring deforestations. This design was especially aimed at identifying and minimizing deforestations, and in fact resulted in a limited extent of forest area reductions that could not be captured.

On the other hand, there were processes that resulted in an “increase of the forest area over the past decades that was only captured at subsequent forest surveys, and which was not regarded so much important to track. The majority of these “increases” is due to the following causes:

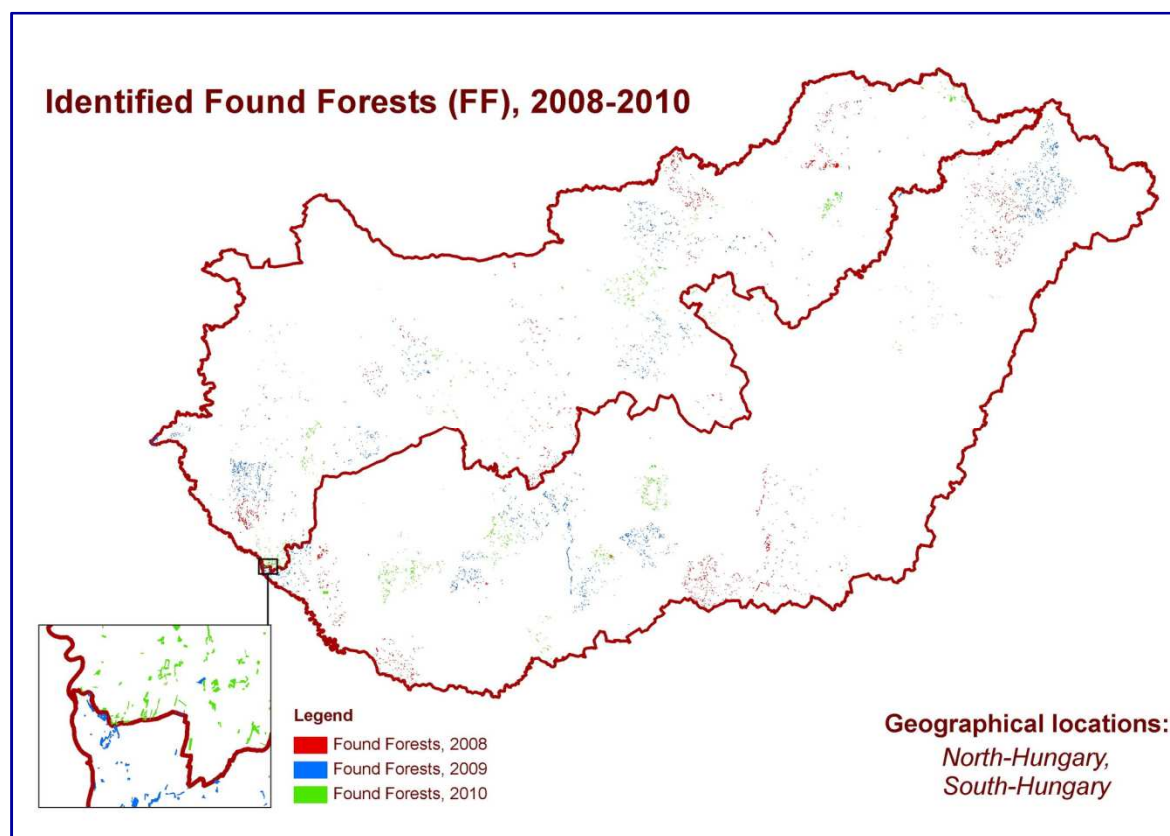
- natural expansion of the forest area, i.e. natural establishment of stands (about 20% of the cases),
- re-classification of land (i.e., areas of “croplands”, “grasslands” or “settlements” etc.

that are found to be covered by trees are reclassified as “forests”, about 60% of the cases)

- geodesic re-measurements of previously existing stands at subsequent surveys (about 20% of the cases).

The found changes of the total forest area in any inventory year are thus only partly physical and actual increases of the “forest” area, and partly are due to the continuous development of the forest inventory and the land use inventory in general. The forests that are “found” in an inventory year are termed and classified as “found forests” (FF). FF often come into existence due to natural or unknown reasons, but often to unregistered earlier afforestations, which must be re-classified when identified.

Most stands in the FF category have been identifiable individually since 2008, their area being 4,798, 4,303 and 3,182 ha, and their average growing stock being 126.9, 121.9 and 123.4 m<sup>3</sup>ha<sup>-1</sup> in 2008, 2009 and 2010, respectively. The remaining parts of the changes in the total forest area are due to unregistered or illegal afforestations and any other changes as identified by the re-measurement of forest area by the continuous forest inventory. The area of these remaining parts cannot be broken down to stands at the moment.



**Figure 7.3.** Identified found forest on subcompartment-level

For earlier inventory years, we only identified the total area of FF, and conducted a sampling of management plans to establish their specific growing stock (m<sup>3</sup>/ha). From these values, total growing stock of FF could be estimated for each inventory year by using the total FF area. The mean growing stock of all FF that were identified before 2007 is 129.6 m<sup>3</sup>/ha.

In each inventory year, the newly identified FF must be excluded from the FL-FL subcategory in that year, otherwise the volume stock changes, and thus removals of carbon, would be overestimated for the FL-FL subcategory. This is because neither the area, nor the carbon stocks of these FF are included in the FL-FL subcategory in the previous inventory year as they are not yet known then.

Note, however that these FF become parts of the FL in the new inventory year, because the

definition of FL-FL starts over in each calendar year, and not in relation to a fixed point in time, which is the case in the land under Art. 3.4 Forest Management activity under the Kyoto Protocol when the beginning of the period of the definition of Forest Management, i.e. 1990, is fixed.

Since there is no evidence of the formal status of these forest before entering NFD (natural expansion of the forest area is unknown *ab ovo*; unregistered afforestations escaped from administration's perspective), the FF cannot be regarded as managed forest. Harvest statistics incorporate all harvest of Total Forest (TF), including FF, the estimation of non-CO<sub>2</sub> emissions is a conservative approach in this way.

A complete assessment of FF with respect to the area and carbon stock changes in 2010 is presented in Chapter 11.2.2. We note once again that both the area and the carbon stock changes in the FF are excluded from both FL-FL and L-FL in the inventory year when these FF are identified.

### 7.3.1 Forest Land remaining Forest Land (CRF sector 5.A.1)

#### 7.3.1.1 Category description

The main characteristics of the FL-FL category can be found in Table 7.7. Note that data was recalculated in this year. The largest changes are due to re-defining L-FL land, which has resulted in substantial changes in emissions and removals in both the FL-FL and the L-FL categories, however, their sum has not much changed (see 7.3.6. section for details).

**Table 7.7. Emissions (+) and removals (-) in the FL-FL sub-category by gas and inventory year**

Inventory year	Area of subcompartments	CO <sub>2</sub>	CH <sub>4</sub>	CO	N <sub>2</sub> O	NO <sub>x</sub>
	(ha)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1985	1,748,164	-1,291	1.38	12.05	0.0095	0.34
1986	1,750,861	-3,354	1.39	12.20	0.0096	0.35
1987	1,753,827	-3,734	1.34	11.75	0.0092	0.33
1988	1,756,259	-3,922	1.30	11.39	0.0089	0.32
1989	1,762,801	-2,619	1.30	11.37	0.0089	0.32
1990	1,768,774	-2,249	1.20	10.50	0.0082	0.30
1991	1,773,942	-2,526	1.17	10.22	0.0080	0.29
1992	1,780,140	-3,191	1.07	9.36	0.0074	0.27
1993	1,785,094	-4,807	0.94	8.26	0.0065	0.23
1994	1,788,184	-5,300	0.97	8.45	0.0066	0.24
1995	1,793,517	-5,323	1.01	8.83	0.0069	0.25
1996	1,797,602	-1,360	1.10	9.60	0.0075	0.27
1997	1,801,572	-1,564	1.12	9.78	0.0077	0.28
1998	1,804,219	-2,480	1.09	9.53	0.0075	0.27
1999	1,809,551	-775	0.98	8.55	0.0067	0.24
2000	1,813,966	316	1.31	11.45	0.0090	0.33
2001	1,817,339	-1,051	1.18	10.35	0.0081	0.29
2002	1,821,574	-419	1.19	10.41	0.0082	0.30
2003	1,822,625	-2,457	1.17	10.27	0.0081	0.29
2004	1,828,804	-1,457	1.02	8.89	0.0070	0.25
2005	1,831,429	-3,568	1.62	14.16	0.0111	0.40
2006	1,840,911	-1,510	1.02	8.93	0.0070	0.25
2007	1,851,638	-1,723	1.46	12.74	0.0100	0.36
2008	1,864,835	-2,933	1.02	8.90	0.0070	0.25
2009	1,875,758	-2,041	1.00	8.76	0.0069	0.25
2010	1,882,034	-1,995	1.07	9.39	0.0074	0.27

#### 7.3.1.2 Methodological issues – CO<sub>2</sub> emissions and removals

As mentioned above, the general methodology to estimate emissions and removals in the forestry sector is based on the IPCC methodology provided in GPG for LULUCF (IPCC, 2003) and Guidelines (IPCC, 2006). 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 and soil 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.

#### 7.3.1.2.1 Changes in carbon stocks in the biomass pools

Changes in carbon stocks in the biomass pools are estimated using the stock-change method. Due to the nature of the Hungarian forestry statistics, estimates of total volume of all forests in the country are available annually, thus, we can develop carbon stock change estimates for each inventory year.

This method has been applied in the national greenhouse gas inventory since 2006. Previously, the changes had been calculated, following the early advice of the Revised Guidelines (IPCC, 1996), using the "IPCC default method" (better termed as a process-based method or gain-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 (which is also consistent with what the IPCC 2006 Guidelines suggest in section 4.2.1.1. of Volume 4).

Fortunately, the National Forest Database contains also aggregate annual statistics on total growing stocks by species and age classes. These statistics are produced by a bottom-up approach, i.e. growing stocks of stands by species and age classes are added up. There are uncertainties around these statistics, too, however, they are regarded smaller than those associated with a gain-loss method, 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 on emissions and removals can be made separately for any of these processes.

Equation 2.8 of the Guidelines (IPCC, 2006), which is a follow-up of 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:

$$\Delta C_B = (C_{t_2} - C_{t_1}) / (t_2 - t_1) \text{ and}$$

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

where

$\Delta C_B$  = carbon stock changes of biomass (tonnes C)

$C_t$  = carbon stock at time  $t$  (tonnes C)

$V_t$  = growing stock 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.

We repeat here that neither the area nor the growing stock (and thus carbon stock) of the forests that are found in the year  $t_2$  are included in that year (because these FF are not known in year  $t_1$ ). Therefore, when these forests become known to the inventory in year  $t_2$  as FF (and not as afforestations), they do not become parts of the L-FL category in  $t_1$ , and both the area as well as the volume (and thus carbon) stocks are excluded (i.e., subtracted) from the respective values for year  $t_2$  to avoid that the carbon stocks, and not the carbon stock changes, enter the equation. In other words,  $V_2 = V - V_{FF}$  where  $V$  is the total volume stock of all forests in the FL-FL category at time  $t_2$ , and  $V_{FF}$  is the total volume stock of forests that are found in year  $t_2$ .

(Note that the above procedure underestimates true volume stock changes of all physically existing forests, because it excludes the volume stock change of the FF as we do not *know*



the growing stock of the stands of the FF one year before they enter the forest statistics. This approach inevitably results in a conservative approach to accounting because, although this land of young forests, whose mean age is 25.5, 22.2 and 24.7 years in 2008, 2009 and 2010, respectively, is obviously a net sink, and this sink cannot be accounted for.)

The application of the above equations is possible because, as it was mentioned above, the forest inventory is continuous to enable the preparation of forest management plans, which is achieved by surveying all individual stands once in every 10 years.

During the continuous survey of the forest inventory, the main stand measures (such as height, diameter, basal area, and density) are estimated by various measurement methods. The survey also includes mapping of the forest area. 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.

The forest inventory is conducted by the staff of the Central Agricultural Office Forestry Directorate, which is about 300-400 forest engineers strong. The inventory data is stored by stand in a computerized database, i.e. the National Forest Database (NFD).

Tree volume in the forest inventory is calculated from measured diameter and height of sample trees using volume functions by Kiraly (1978), which are in turn based on volume tables by Sopp et al. (1974).

Concerning wood density, a new set of data was introduced in 2010 (i.e., since inventory year 2008). The current values (Table 7.8), which replace previous data that were oven-dry density values and which are used across all reporting years, are much more detailed by species than before, and are basic wood densities based on a thorough revision of previous data reported in literature combined with re-measurements of wood densities for some species (Somogyi, 2008.)

**Table 7.8.** Basic wood density values for the main species and species groups in Hungary as used in previous submissions (i.e. until 2010, "previous" values, Babos et al. 1979, and Kovács, 1979) and as used in this and subsequent submissions ("revised" values, Somogyi, 2008)

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

Species or species group	Previous density (t/m <sup>3</sup> )	Revised density (t/m <sup>3</sup> )
<i>Picea abies</i>	0.53	0.39
<i>Larix deciduas</i>	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<sup>3</sup>) 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 to volume estimates.

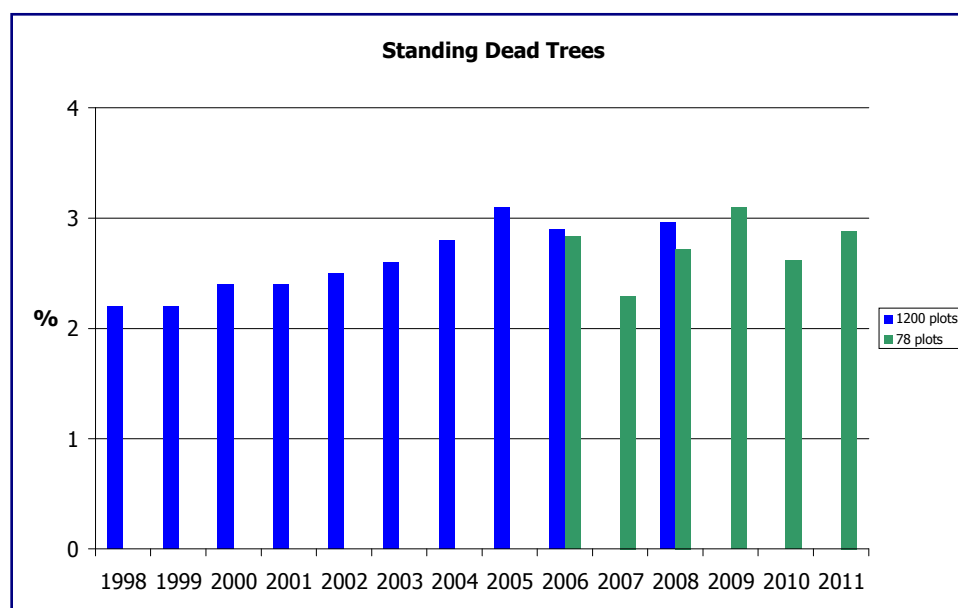
With respect to the below-ground biomass, a general value for the root-to-shoot ratio (R) is applied. Until a few years ago, carbon stock changes in the below-ground biomass carbon pool were not accounted for. Since 2006, below-ground biomass carbon stock changes have also been reported, however, in 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 (calculated on the bases of the area of forest subcompartments) are 173 m<sup>3</sup> per ha (in 1990) and 187 m<sup>3</sup> per ha (in 2010), corresponding to an average aboveground biomass of 95 t ha<sup>-1</sup> (in 1990) and 103 t per ha (in 2010), respectively, a conservative value of R of 0.25 is used for all species. The IPCC default values have relatively high uncertainty, but we believe that the probable value for the Hungarian forests is significantly higher than 0.25, which is thus a conservative value as long as forests are net sinks.

Concerning the carbon fraction of dry wood, the IPCC default values, i.e. 0.48 and 0.51 tonnes C tonnes per biomass are used for broadleaves and coniferous species, respectively. The estimated net removals resulting from the above calculations are reported in Table 7.7 above.

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

In Hungary, data has not been collected systematically, not 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, rather than to lose carbon, in the medium-term.

To demonstrate that DOM is not an emitting pool, we present the results published in the European ICP-Forest, Forest Focus and Life+ programs on forest health. These results are based on a small but systematic sampling, and show a varying and slow, but net accumulation of the number of standing dead trees until ca. 2005, and a not decreasing trend (at least) after.



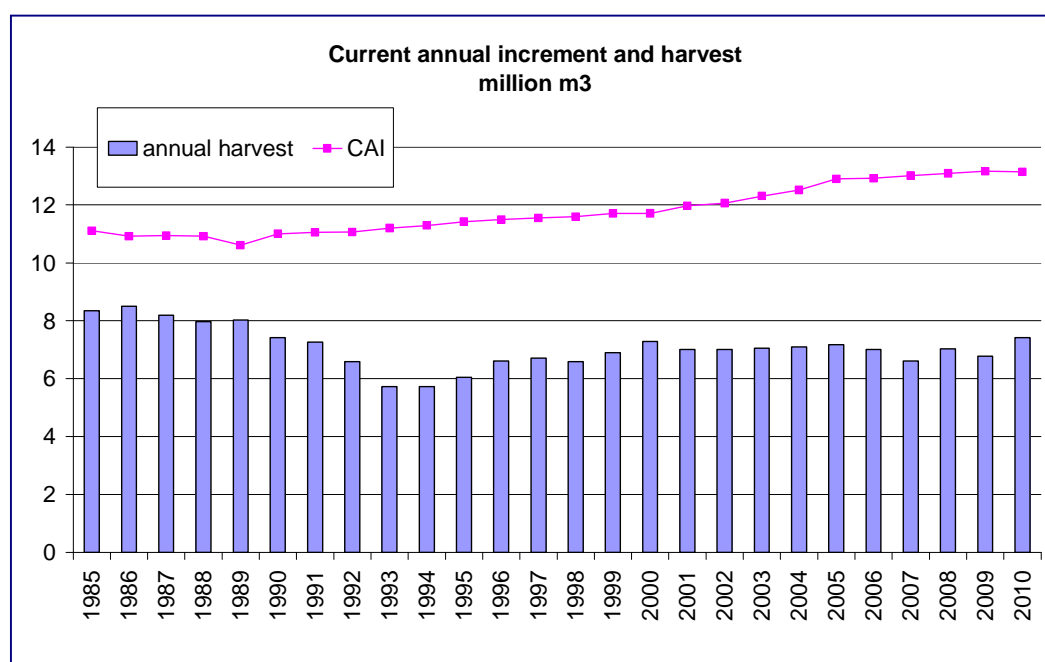
**Figure 7.4.** The amount of standing dead trees in the Hungarian forests (number of trees in the sample, %). Data source: IPC-Forest, Forest Focus, Life+ and FMOS (Forest Monitoring and Observation System) program, and Somogyi and Zamolodchikov, 2007. Note that the number of plots surveyed plots reduced because of financial reasons

The slow but steady increase of the amount of standing dead trees, and in general that 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 7.5, too, which shows the amount of estimated current annual increment in relation to harvest statistics. The difference of increment and harvests is large enough to claim not only sustained yield, which is also obvious from the growing trend of total volume stocks for the last two decades, but also to assume that a lot of the uncut trees die due to the well-known self-thinning rule in stands where density has become high, so the amount of deadwood keeps increasing, too. In the last decades, the close-to-nature forest management has been promoted in Hungary, and clearcuts were restricted, so we can assume 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, at least on average in the long run, that these pools are not sources, and their carbon stock changes are zero. (See also the demonstration in Chapter 11 that soils are not a source.)

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 saturated yet.

Concerning harvested wood products, changes in the carbon stocks in this pool are not reported. 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 cycle) are about the same. Note, however, that, indeed, and as reported in our Submission on Forest Management Reference Levels (SFMRL Hungary, 2011), small changes have been estimated in a study (Rüter, 2011) concerning the carbon stock changes

of harvested wood products when applying a first-order decay function with default half-lives of two years for paper, 25 years for wood panels and 35 years for saw wood, which makes it not practicable to report them.



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

#### 7.3.1.2.3 CO<sub>2</sub> emissions from liming

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

#### 7.3.1.3 Methodological issues – non-CO<sub>2</sub> emissions

Estimated non-CO<sub>2</sub> emissions include those from burning of slash on-site and, for the last couple of years, from wildfires. Non-CO<sub>2</sub> emissions from the mentioned 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<sub>2</sub> emissions from these sources are accounted for in the biomass pool, because we apply the stock-change method. Theoretically, these emissions include carbon of CO and CH<sub>4</sub>. However, these gases are nevertheless reported (complying with the methodology of the *GPG for LULUCF (IPCC, 2003)* 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<sup>3</sup> of wood removed from forest, see the graph above, from which the amount of slash was calculated using average values by species (see Table 7.9 below), which were developed in former country-wide specific project for statistical purposes). In addition, expert judgment 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<sub>4</sub>, 0.06 for CO, 0.007 for N<sub>2</sub>O, and 0.121 for NO<sub>x</sub>. 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<sub>4</sub>, 28/12 for CO, 44/28 for N<sub>2</sub>O, and 46/14 for NO<sub>x</sub>.

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 subcompartments. The Forest Authority also collects data on how much per cent of the growing stock of each forest subcompartment 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.) 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.

Wildfires under FL-FL is reported in the CRF. CO<sub>2</sub> emissions attributed "IE", and reported under biomass pool, because of the stock change method: the amount of C burned in fire is logged as a change of growing stocks between the beginning and the end of the year. Non-CO<sub>2</sub> emissions are reported separately.

Wildfires are very erratic in nature 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. We think, that it would be misleading to type these area-data into the CRF, that's why cells of 1985-1998 are remained "NE".

Unfortunately no data is available for burned area in wildfires between 1985-1998 at all. We used a simple model to estimate biomass burned in wildfires to calculate emissions based on the mean share of biomass burned (kg dm) of wildfires and controlled burning between 1999-2009.

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

All non-CO<sub>2</sub>-emissions are reported under FL-FL, because of its minor contribution to the overall emissions it is not practicable to report separately.

**Table 7.9.** *The amount of controlled burning and forest fires based on all available data*

Reporting year	Harvested volume (m <sup>3</sup> )	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m <sup>3</sup> )
1985	8,345,562	999,660	NE	NE	NE
1986	8,500,991	1,012,554	NE	NE	NE
1987	8,193,145	975,181	NE	NE	NE
1988	7,960,397	945,002	NE	NE	NE
1989	8,031,779	941,890	NE	NE	NE
1990	7,415,162	867,795	NE	NE	NE
1991	7,255,202	846,173	NE	NE	NE
1992	6,588,569	775,646	NE	NE	NE
1993	5,723,745	683,589	NE	NE	NE
1994	5,717,468	697,710	NE	NE	NE

Reporting year	Harvested volume (m <sup>3</sup> )	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m <sup>3</sup> )
1995	6,049,151	728,540	NE	NE	NE
1996	6,603,733	791,934	NE	NE	NE
1997	6,713,101	807,859	NE	NE	NE
1998	6,578,931	786,791	NE	NE	NE
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
2009	6,773,537	700,299	329	2,696	7,000
2010	7,424,046	756,271	69	625	5,324

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

#### 7.3.2.1 Category description

Carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) are reported in this category. As assumptions that non-biomass pools are net sinks are much more valid for this category, 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, Somogyi-Horváth, 2006a, Somogyi-Horváth, 2006b. However, there are some indications that converting grassland to forest may lead to some emissions, see Horvath, B. 2006. Because most of the huge amount of marginal lands that are afforested are former croplands, and also because of biodiversity concerns, the overwhelming majority of conversions occur on abandoned croplands (81% of afforestation 1990-2009, from survey of CAO, Forestry Directorate), so no major emissions from soils are suspected during conversion. See more details on non-biomass pools in section 11.)

#### 7.3.2.2 Methodological issues – CO<sub>2</sub> emissions and removals

The estimated area of, and CO<sub>2</sub> emissions from, this category are summarized in Table 7.10 below.

Modelling of growing stock and increment (and via removals) of L-FL is needed because the area of L-FL cannot be identified on subcompartment-level between 1985 and 1989.

In the current submission the net removals (NR) of L-FL were recalculated between the whole 1985-2010 period by applying, for the first time in reporting, the default 20 years transition period.

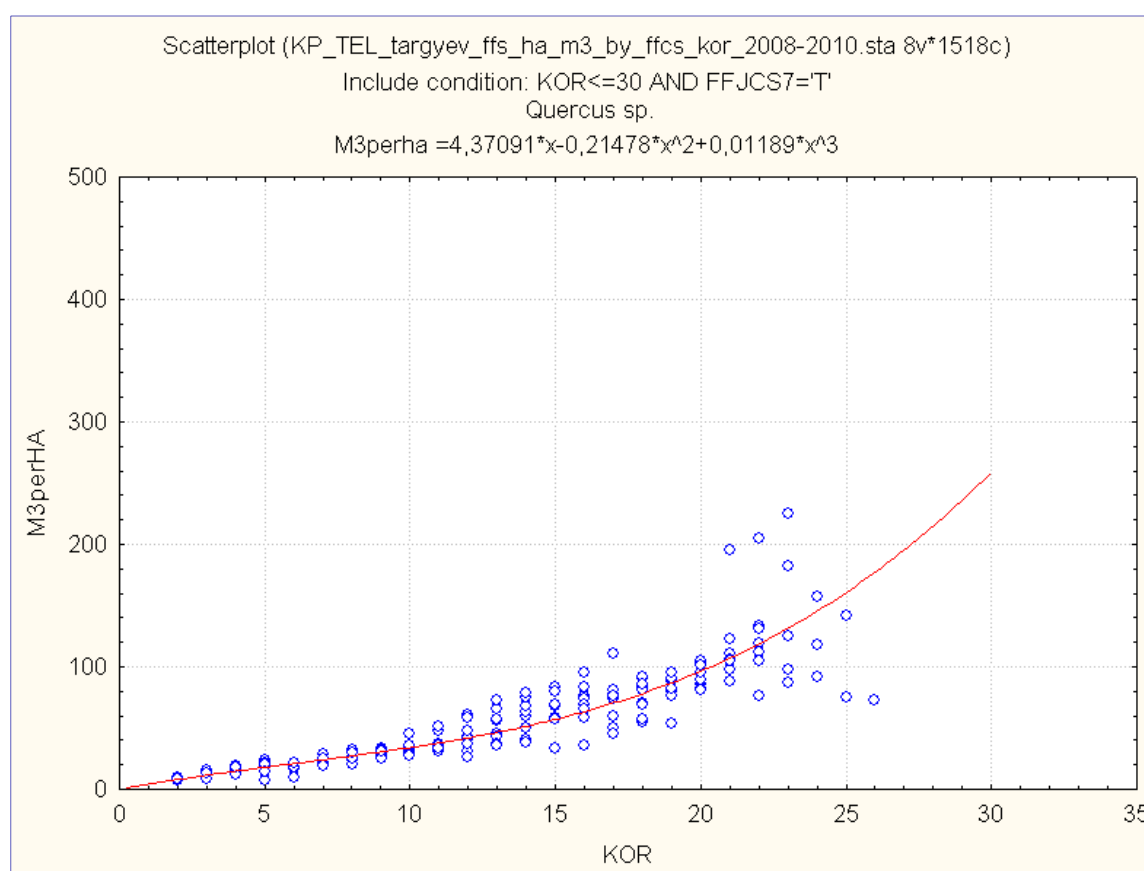
The formal solution was based on the official local reports of initial planting and finishing of afforestations as per domestic regulations. According to these regulations, the time the various stands were accounted for in L-FL category, i.e. the time that elapses from soil preparation until the stand is regarded as forest, changes by species, site, as well as climatic



conditions and the appearance of pests/pathogens. This time could 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 IPCC 2006 Guidelines admits of this inhomogeneous lead-time, but we also considered the argument regarding the soils, and the shorter lead-time may not be sufficient to reach a new equilibrium level after the conversion. On the other hand, we have developed our database system to allow for a new classification of the stands.

The new model is based on the same yearly area of initial planting of afforestations by target stand-type (*Quercus* sp., *Quercus cerris* and other hard broadleaved, *Fagus*, *Robinia*, Hybrid Poplar and *Salix* sp., Indigenous poplars and other soft broadleaved, Coniferous), published by the CAO Forestry Directorate 1985-2010. The data is logged by the Forest Authority and primarily has a subsidy-supporting roll, however, based on a separate study, only 91.8% of this area appears in the National Forest Database as a forest (based on data of 1990-2010).

We have developed a simplified yield table for the young forests by regressions between ages and stand volume by the 7 target stand-types (see Figure 7.6 as an example for *Quercus* sp.). This was necessary because, when stands are young, mean stand height that is registered in the NFD cannot be used as a predicting variable as estimates are rounded to meters (i.e., decimals are not used). The sample set was the forests of AR category as in 2010 in the NFD; the growing stock of these young stands is derived by yield tables regularly. On a sample set of volume data over age, polynomial (3<sup>rd</sup> degree) regressions were fitted for species of long rotation age, and linear regressions for species of short rotation age. The curves were forced to start from the origo. The regression coefficients are above 0.9, and the regression parameters are significant in each case. Increment was then developed using these yield tables. The resulting increment is thus a smoothed one, and does not represent interannual variation due to e.g. variation of growing conditions.



**Figure 7.6.** An example of regression of age (KOR) and stand volume per hectare (M3perHA). For this fitting, data of *Quercus* sp. (T) afforestations was used as in AR 2008-2010



In the model to estimate carbon stock changes for the L-FL category, the area of the initial planting of a stand (by target stand-type) is entered into the L-FL category (from 1985 to 2010). Afforestation is deemed to have started when, after soil preparation, land has been "initially" planted, i.e. propagation material is planted on the area for the first time. (Subsequent beating up may be carried out depending of the success rate of this initial planting.) The area is then rolled over the 20 years transition period, and is multiplied each inventory year by the increment for the age of the stand in the respective inventory years. Concerning converting volume to biomass and carbon stock changes, methodologies used in this category are the same as used in the FL-FL category as described above.

**Table 7.10.** Area, as well as CO<sub>2</sub> emissions and removals on land converted to forest land

Inventory year	Area (ha)	CO <sub>2</sub> removals (Gg)
1985	7,476	-97
1986	14,972	-145
1987	22,864	-196
1988	31,348	-257
1989	38,633	-297
1990	45,127	-331
1991	51,461	-370
1992	58,200	-420
1993	61,244	-418
1994	63,957	-435
1995	67,904	-475
1996	74,144	-538
1997	81,997	-612
1998	89,742	-671
1999	97,961	-739
2000	107,203	-821
2001	119,605	-935
2002	133,606	-1,054
2003	144,948	-1,130
2004	152,098	-1,161
2005	151,851	-1,153
2006	157,561	-1,223
2007	167,556	-1,306
2008	165,994	-1,211
2009	163,588	-1,175
2010	164,361	-1,157

With respect to deadwood and litter, the assumption is made that the stock change is zero, and it is thus not reported. This is a justified and conservative assumption, because both the litter and deadwood pools are zero before the conversion, and increase after the conversion.

Losses of conversion from other land-use categories (Perennial Cropland: vineyards, orchards and other woody plantations) were calculated based on activity data (area) from the land transition matrix and default IPCC conversion factors.

### 7.3.2.3 Methodological issues – non-CO<sub>2</sub> emissions

All non-CO<sub>2</sub>-emissions are reported under FL-FL because of its minor contribution to the overall emissions it is not practicable to report separately.

### 7.3.3 Forest Land converted to other land uses (CRF sector 5.B.2.1, 5.C.2.1, 5.D.2.1)

Forest land in Hungary is rarely converted to other land uses, and the conversions only include conversions to cropland, grassland and settlements. Conversions from forest land to other land use types are generally prohibited by the Forest Act, and can take place only after the Forest Authorities grant a permission. The area of conversions can thus be surveyed, and is estimated using the land conversion database of the Forest Authorities. However, these statistics are only available since 1985, and the average of the period 1985-1989 is used for the previous years for which estimates are also needed to run up the estimation of emissions from soils.

#### 7.3.3.1 Methodological issues – CO<sub>2</sub> emissions and removals

CO<sub>2</sub> emissions and removals are estimated for the biomass and soil pools. For the other pools, we assume that carbon stock changes are close to zero, i.e. insignificant, and it is not practicable to estimate them.

For biomass, we follow the same methodology that is detailed in the FL-FL category. Note that this is different from earlier years (reporting years 2010 and before) when we did not explicitly differentiate the FL converted to other land uses category, and when the carbon stock change estimate for the FL-FL category included that of deforestations. Beginning 2010, we report emissions from deforestations. In the carbon stock change calculation, we assume that the biomass carbon stock is equal to zero after the conversion, so the total carbon stock of the deforested land right before the deforestation is completely emitted.

For soil, we follow the default method of IPCC (2003, 2006). In this method, a 20-year-long period is assumed during which the carbon stock of the forest soil, which for this estimation is deemed to be in equilibrium before the conversion, reaches a new equilibrium level after the conversion. Thus, for each conversion type (i.e. FL to CL, FL to GL, and FL to SE), the area is needed for each inventory year. To estimate the annual carbon stock change of a converted land for an inventory year, its area must be multiplied by 1/20<sup>th</sup> of the difference between the equilibrium soil carbon stock of the land use type before the conversion (i.e., FL) and after the conversion (i.e., CL, GL and SE). For each piece of land converted, the same amount of carbon stock changes are accounted for 20 consecutive years. Thus, for any conversion type and for any inventory year, the total annual carbon stock changes of the newly deforested areas, as well as those of the previous 1-19 years must be added up. Finally, carbon stock changes for the conversion types must also be added up.

For the estimation of carbon stock changes by conversion type, we identified sub-categories by climate, soil management and input type (see section 7.4.2.2.1). Based on a country-wide classification, this resulted in the distribution of land within conversion types. All deforested land was then classified into conversion types, thus, we got areas by conversion type and the within-conversion type categories. Finally, default IPCC soil reference and other factors were used to estimate the difference of carbon stock change between FL and land use type after conversions.

The areas identified, and the resulting CO<sub>2</sub> emissions are included in Table 7.11.

**Table 7.11.** *The area, as well as CO<sub>2</sub> emissions and removals from soils on land converted from forest to other land uses*

Inventory year	FL converted to CL		FL converted to S		FL converted to GL		All conversions from FL to other land use	
	Area (ha)	CO <sub>2</sub> emissions (Gg)	Area (ha)	CO <sub>2</sub> emissions (Gg)	Area (ha)	CO <sub>2</sub> emissions (Gg)	Area (ha)	CO <sub>2</sub> emissions (Gg)
1985	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1986	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1987	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1988	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1989	94.8	3.250	210.5	6.772	20.9	0	326.1	10.023
1990	180.0	3.396	392.6	7.066	40.3	0	612.9	10.462
1991	59.9	3.336	167.0	6.996	12.9	0	239.8	10.332
1992	44.4	3.250	71.8	6.772	9.4	0	125.6	10.023
1993	12.7	3.109	233.1	6.809	82.7	0	328.6	9.918
1994	28.4	2.996	162.5	6.732	27.3	0	218.2	9.727
1995	53.2	2.924	244.1	6.786	60.5	0	357.8	9.710
1996	78.7	2.897	188.1	6.750	79.0	0	345.9	9.647
1997	192.1	3.064	239.6	6.797	90.3	0	522.0	9.861
1998	88.9	3.054	271.4	6.895	41.7	0	402.0	9.948
1999	26.8	2.937	277.9	7.003	90.7	0	395.4	9.940
2000	67.8	2.891	594.9	7.621	56.4	0	719.1	10.512
2001	61.4	2.833	358.6	7.860	100.9	0	520.9	10.693
2002	108.9	2.857	439.5	8.228	89.2	0	637.5	11.085
2003	25.7	2.738	523.4	8.732	44.1	0	593.3	11.470
2004	74.2	2.702	750.5	9.600	119.1	0	943.8	12.303
2005	71.2	2.661	313.2	9.765	26.7	0	411.1	12.427
2006	44.4	2.574	443.4	10.140	20.8	0	508.6	12.715
2007	16.4	2.440	192.5	10.111	36.6	0	245.5	12.551
2008	97.0	2.443	162.0	10.030	35.0	0	293.8	12.473
2009	56.2	2.374	296.8	10.168	102.7	0	455.0	12.542
2010	59.4	2,155	102.3	9,700	46.6	0	208.3	11,855

### 7.3.3.2 Methodological issues – Non-CO<sub>2</sub> emissions and removals

As deforestations rarely occur in the country, it is a close-to-zero probability that wildfires affect these areas. In the last years, no wildfires occurred on land that later (in the same year) was converted to other land use. Therefore, emissions from wildfire are reported as not occurring.

On the other hand, controlled burning (burning of slash) occurs on this land. The methodology to estimate emissions from this source is the same as described in section 7.3.1.3.

N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland also occur on this land. The basis for the estimation of these emissions is the assessment of the CO<sub>2</sub> emissions from soils as presented above. Using these CO<sub>2</sub> emissions for cropland, we applied Equations 3.3.14 and 3.3.15 of the GPG (IPCC, 2003). As no country specific emission factors exist for this tiny source of emissions, we applied the IPCC default factors for the estimation.

### 7.3.4 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. This year, Hungary performed a more detailed, although still partial uncertainty analysis applying error propagation equations of approach 1 (see:

[http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/)). In the forestry sector, removals being accounted for are caused mainly by tree growth, thus, uncertainty occurred in carbon stock change of the biomass was of high priority. Hungary made efforts in order to quantify uncertainties based on its own data (see the link cited above). However, further development is clearly needed by applying more-sophisticated methods of higher Tiers including Monte Carlo simulation and the comparison of its results with those of error propagation

Information on uncertainties includes, among others, information on completeness, accuracy, and non-quantifiable elements. Concerning *completeness*, some minor 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, and underestimation of net removals.

With respect to *accuracy*, the reported estimated values are generally accurate as far as practicable. An example for this is the revised basic density values. Where uncertainty seems to be high, and for *non-quantifiable factors*, the principle of conservativeness is always applied. Conservative estimates are used for volume stocks and their change. Conservative assumptions are used for the root-to-shoot ratio, and in the case of carbon stock changes in the soil, litter and deadwood pools.

It is probable that total forest area is underestimated, which is shown by the fact that the forest inventory still identifies new forest areas each year. One reason for that can be afforestations that are done by land owners from their own budget (i.e. not using EU subsidy, which is the main source of afforestations). It is also probable that, due to conservativeness built into the methods of the national forest inventory, both volume stocks, and therefore, volume stock changes are underestimated. The basis for this assessment is a sample-based inventory which, currently as unofficial statistics, indicates higher volume stocks and higher volume increment each year. Finally, wood harvests also seem to be underestimated a bit due to illegal cuttings, which, according to some expert judgements, may account for some 250,000 m<sup>3</sup> of harvest that is additional to the annual official figure of around 7 million m<sup>3</sup> (this figure being variable from year to year). Considering the underestimation of volume stock and wood harvests in combination, volume stock changes are most probably underestimated.

As mentioned before, 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.

For carbon stock changes in biomass, the system of calculations allows for the use of even simpler sensitivity analysis than before. This is especially true if only the major sources of CO<sub>2</sub> emissions and removals are considered, which the bulk of all emissions and removals. The reason for this is that the equation inherent in the calculation is simple: only volume stock changes, wood density, root-to-shoot ratio, and carbon fraction factors are involved.

With respect to the uncertainty of the *annual* CO<sub>2</sub> emissions, 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. A detailed uncertainty analysis for the biomass carbon stock changes is presented in Chapter 11 (Section 11.3.1.5), and below a few additional considerations are made.

It can be concluded that, with regard to carbon stock change estimation, many sources of error were 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.

With regard to non-CO<sub>2</sub> emissions, the estimation is accurate as far as practicable for the years for which we have data. Data collection has improved a lot for most recent years, the estimate for 2008 being the most accurate one.

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 all inventory years. Although no information is currently 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.

Finally, both methods and data are applied consistently throughout the entire reporting period. This results in a consistent time series of the GHG information. Please refer to Section 11.3.1.5 for further details.

### Error propagation

Uncertainty estimation by error propagation was based on equations having been used for assessment of emissions/removals of various LULUCF categories. The results are shown in Table 7.12. Note that it was impossible to aggregate emission factor uncertainties on category-level due to the complex calculation methodology of emissions/removals related to forest land. Thus, implied emission factor uncertainties were determined on category-level. It means that activity data and combined uncertainties were aggregated to category-level and implied emission factor uncertainties were calculated from them following error propagation rules (Equation 3.1, 2006 IPCC Guidelines). Activity data were (variable type – sink/source): standing volume growth (m<sup>3</sup>) – biomass pool, volume of the removed trees (m<sup>3</sup>) – slash burning, volume of the burned trees (m<sup>3</sup>) – wildfires, total deadwood volume (m<sup>3</sup>) – deadwood, size of area (ha) – soil. A detailed description of uncertainty estimation is available online at:

[http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/).

**Table 7.12.** Activity data, implied emission factor and combined uncertainties expressed by the half-width of percentage confidence intervals (confidence level = 95 %) by sink/source categories. Deforestations were classified according to the post-deforestation uses if corresponding data were available.

Category	Sink/source	Gas	Activity data	Implied emission factor	Combined
FL-CL	soil	CO <sub>2</sub>	3.81	91.30	91.38
FL-CL	biomass (stock-change)	CO <sub>2</sub>	25.16	45.00	51.56
FL-FL	biomass (stock-change)	CO <sub>2</sub>	5.71	25.39	26.02
FL-FL + L-FL	slash burning	CH <sub>4</sub>	0.98	15.50	15.53
FL-FL + L-FL	slash burning	CO	0.98	17.53	17.56
FL-FL + L-FL	slash burning	N <sub>2</sub> O	0.98	40.56	40.57
FL-FL + L-FL	slash burning	NO <sub>x</sub>	0.98	40.02	40.03
FL-FL + L-FL	wildfires	CH <sub>4</sub>	43.21	17.69	46.69
FL-FL + L-FL	wildfires	CO	43.21	20.76	47.94
FL-FL + L-FL	wildfires	N <sub>2</sub> O	43.21	52.88	68.29
FL-FL + L-FL	wildfires	NO <sub>x</sub>	43.21	52.14	67.72
FL-GL	biomass (stock-change)	CO <sub>2</sub>	23.38	43.39	49.29
FL-L	deadwood	CO <sub>2</sub>	14.08	14.27	20.05
FL-L	biomass (stock-change)	CO <sub>2</sub>	13.42	39.46	41.68
FL-L	slash burning	CH <sub>4</sub>	13.37	17.10	21.71
FL-L	slash burning	CO	13.37	19.23	23.42
FL-L	slash burning	N <sub>2</sub> O	13.37	43.83	45.82
FL-L	slash burning	NO <sub>x</sub>	13.37	43.25	45.27
FL-SE	soil	CO <sub>2</sub>	2.44	96.38	96.41
FL-SE	biomass (stock-change)	CO <sub>2</sub>	18.15	40.82	44.67
L-FL	biomass (stock-change)	CO <sub>2</sub>	19.62	47.90	51.76

### 7.3.5 Category-specific QA/QC and verification

Calculations are generally based on the activity data taken from the National Forest Database, and the databases of the Forest Authorities on afforestations and deforestations. These databases are the most accurate ones 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 staff 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 increasing accuracy of the Database in recent years.

Since 2011 the GHG inventory is completed by the CAO Forestry Directorate (formal National Forest Service), i.e. the institute that runs the National Forest Database and other mentioned databases.

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., the preparation and the QA of the GHG inventory) has also improved the data quality. Final checks and integration of the data into the GHG inventory was performed by the Hungarian Met Office.

Data verification was, and continuously is, 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 arithmetic used in the GHG inventory were double-checked. All background information is archived by the inventory agency. Thus, the correctness of the estimation methodology is in principle verifiable.



### 7.3.6 Category-specific recalculations

Removals of the L-FL were recalculated between 1985-2010 due to switching to the system of assuming the default 20 years lead-time. As a consequence, the FL-FL removals also changed. A small calculation error was also corrected to estimate net removals, which is based on the annual growing stock data of total forest under forest management plans (Total Forest). The growing stock data regards the end-of-the-year date (i.e., 31 December) each year. The equation applied is the following:

$$[\text{NR of Total Forest}] = [\text{NR of FL-FL}] + [\text{NR of L-FL}] + [\text{C stock of new FF}] - [\text{NR of D}].$$

Losses from Perennial Cropland converted to Forest Land (vineyards, orchards and other woody plantations) were also calculated from 1985-2010 based on activity data (area) from the land transition matrix and default IPCC conversion factors.

Until 2011 submission the whole L-FL area, removals and emissions reported in the Cropland converted to Forest land category. In the current submission we divided the removals of L-FL by the formal land-use category into CF, GF, WF, SF, OF categories proportional to the area of each subcategory from the land transition matrix.

**Table 7.13. Changes in CO<sub>2</sub> emissions from Forest Land (5.A) sector due to recalculations**

5.A.1. FL-FL Gains	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	-1290.8	-2792.8	-3353.7	-3733.9	-3921.5	-2618.9	-2248.8	-2526.5	-3191.3
Submission 2012 [Gg CO <sub>2</sub> ]	-1409.3	-2963.9	-3543.3	-3939.0	-4172.0	-2912.5	-2604.3	-2867.0	-3604.2
Difference [Gg CO <sub>2</sub> ]	-118.5	-171.1	-189.6	-205.1	-250.5	-293.7	-355.5	-340.5	-412.9
Percentage change	9.2%	6.1%	5.7%	5.5%	6.4%	11.2%	15.8%	13.5%	12.9%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	-4807.1	-5300.3	-5323.0	-1360.3	-1563.6	-2480.3	-775.4	315.8	-1050.7
Submission 2012 [Gg CO <sub>2</sub> ]	-5290.6	-5825.8	-5846.5	-1936.2	-2185.9	-3157.4	-1521.7	-518.2	-1934.7
Difference [Gg CO <sub>2</sub> ]	-483.5	-525.5	-523.5	-575.9	-622.3	-677.1	-746.3	-834.0	-884.0
Percentage change	10.1%	9.9%	9.8%	42.3%	39.8%	27.3%	96.3%	-264.1%	84.1%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	-419.3	-2456.7	-1456.7	-3568.0	-1509.9	-1723.3	-2932.9	-2041.1	
Submission 2012 [Gg CO <sub>2</sub> ]	-1408.3	-3533.3	-2559.2	-4649.3	-2683.5	-2930.3	-4039.1	-3076.7	
Difference [Gg CO <sub>2</sub> ]	-989.0	-1076.6	-1102.5	-1081.4	-1173.6	-1207.0	-1106.1	-1035.6	
Percentage change	235.9%	43.8%	75.7%	30.3%	77.7%	70.0%	37.7%	50.7%	



5.A.2.1. CL-FL Gains	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	20.2	30.3	30.0	40.7	53.4	61.6	68.8	76.7	87.1
Submission 2012 [Gg CO <sub>2</sub> ]	21.2	18.7	44.9	9.0	-7.0	-3.3	24.0	-29.4	-7.0
Difference [Gg CO <sub>2</sub> ]	-1.0	11.6	-14.8	31.7	60.4	64.9	44.7	106.1	94.1
Percentage change	-4.5%	61.7%	-33.1%	354.2%	-864.7%	1971.7%	186.1%	-361.4%	1352.1%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	87.1	91.0	99.8	113.3	129.3	142.2	157.1	174.9	200.4
Submission 2012 [Gg CO <sub>2</sub> ]	65.7	90.0	48.1	37.7	10.6	6.1	7.4	13.1	-51.4
Difference [Gg CO <sub>2</sub> ]	21.4	1.0	51.7	75.6	118.7	136.1	149.7	161.8	251.8
Percentage change	32.5%	1.1%	107.6%	200.4%	1122.4%	2237.4%	2029.9%	1234.4%	-490.3%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	227.1	244.3	251.7	250.8	267.4	290.9	272.1	266.1	
Submission 2012 [Gg CO <sub>2</sub> ]	-64.7	-53.3	-58.2	-71.3	-49.0	-99.1	-106.3	-138.9	
Difference [Gg CO <sub>2</sub> ]	291.8	297.6	309.9	322.1	316.4	390.0	378.4	405.0	
Percentage change	-450.9%	-558.2%	-532.6%	-451.7%	-645.3%	-393.4%	-355.9%	-291.6%	

5.A.2.1. CL-FL Losses	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	-46.5	-38.4	-33.3	-35.4	-35.6	-44.8	-41.4	-37.2	-41.4
Difference [Gg CO <sub>2</sub> ]	-46.5	-38.4	-33.3	-35.4	-35.6	-44.8	-41.4	-37.2	-41.4
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	-15.2	-11.0	-17.6	-19.5	-22.6	-19.7	-25.5	-26.5	-15.6
Difference [Gg CO <sub>2</sub> ]	21.4	1.0	51.7	75.6	118.7	136.1	149.7	161.8	251.8
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	
Submission 2012 [Gg CO <sub>2</sub> ]	-18.1	-12.4	-13.7	-2.7	-15.0	-23.4	-12.8	-12.9	
Difference [Gg CO <sub>2</sub> ]	291.8	297.6	309.9	322.1	316.4	390.0	378.4	405.0	
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	

5.A.2.2 GL-FL Gains	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	6.11	9.17	9.09	12.31	16.17	18.64	20.81	23.22	26.36
Difference [Gg CO <sub>2</sub> ]	6.11	9.17	9.09	12.31	16.17	18.64	20.81	23.22	26.36
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	25.64	26.34	28.17	31.26	34.84	37.64	40.76	44.61	49.86
Difference [Gg CO <sub>2</sub> ]	25.64	26.34	28.17	31.26	34.84	37.64	40.76	44.61	49.86
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	
Submission 2012 [Gg CO <sub>2</sub> ]	55.11	58.41	59.33	57.95	60.10	59.38	52.34	48.52	
Difference [Gg CO <sub>2</sub> ]	55.11	58.41	59.33	57.95	60.10	59.38	52.34	48.52	
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	

5.A.2.3 WL-FL Gains	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	0.03	0.04	0.04	0.06	0.07	0.09	0.10	0.11	0.12
Difference [Gg CO <sub>2</sub> ]	0.03	0.04	0.04	0.06	0.07	0.09	0.10	0.11	0.12
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	0.13	0.14	0.16	0.20	0.24	0.27	0.31	0.35	0.38
Difference [Gg CO <sub>2</sub> ]	0.13	0.14	0.16	0.20	0.24	0.27	0.31	0.35	0.38
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	
Submission 2012 [Gg CO <sub>2</sub> ]	0.41	0.42	0.42	0.42	0.44	0.43	0.38	0.36	
Difference [Gg CO <sub>2</sub> ]	0.41	0.42	0.42	0.42	0.44	0.43	0.38	0.36	
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	

5.A.2.4 SL-FL Gains	1895	BY	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	0.21	0.32	0.32	0.43	0.56	0.65	0.73	0.81	0.92
Difference [Gg CO <sub>2</sub> ]	0.21	0.32	0.32	0.43	0.56	0.65	0.73	0.81	0.92
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	IE
Submission 2012 [Gg CO <sub>2</sub> ]	1.10	1.27	1.58	1.98	2.47	2.90	3.41	4.00	4.41
Difference [Gg CO <sub>2</sub> ]	1.10	1.27	1.58	1.98	2.47	2.90	3.41	4.00	4.41
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	100%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> ]	IE	IE	IE	IE	IE	IE	IE	IE	
Submission 2012 [Gg CO <sub>2</sub> ]	4.81	5.06	5.10	5.20	5.52	5.54	5.34	5.37	
Difference [Gg CO <sub>2</sub> ]	4.81	5.06	5.10	5.20	5.52	5.54	5.34	5.37	
Percentage change	100%	100%	100%	100%	100%	100%	100%	100%	

### 7.3.7 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.

Refinement of definitions of DOM pools is also planned, in which the exact distinction of litter and accumulated smaller branches on the ground is needed and is planned to be made. Accumulation models for deadwood in AR areas, based on chronosequences of different forest types, are also planned to be developed.

Non-CO<sub>2</sub> emissions on L-FL area may be calculated separately from FL-FL, to estimate the (otherwise negligible) emissions of these processes. Because of the longer transition period, the short rotation coppices may even have final cuts in 20 years.

A small project started to derive a methodology to sampling possible organic soils (marshes) under forests areas. Until 2014 we may have some data on whether these marshes (approx. 9500 ha) could be regarded as organic soils by GL (Annex 3 A.5, p. 3.37) definitions.

## 7.4 Cropland (CRF sector 5.B)

### 7.4.1 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 converted to another category of land use – cropland still represents the main land use category in Hungary with its 56% proportion of the total area of the country (Figure 7.1). All the plough-lands with annual crops and orchards and vineyards with perennial woody crops and kitchen gardens are classified here. The set-aside croplands are also reported in this category. The areas of Cropland are shown in Table 7.14.

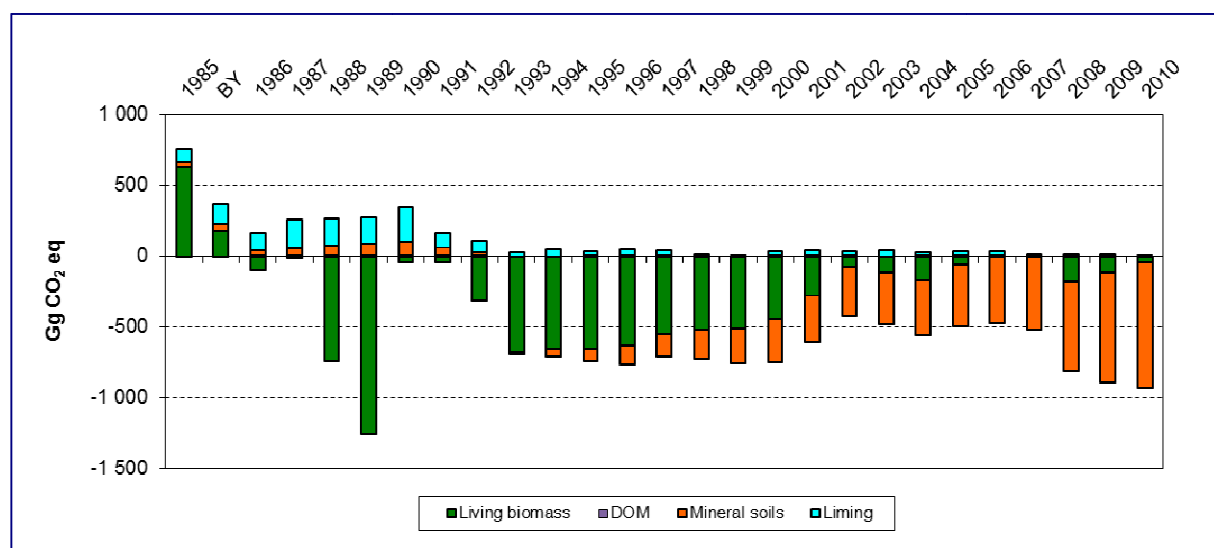
**Table 7.14. Cropland areas 1985-2010 (1,000 ha)**

Year	Area [1,000 ha]				
	Annual Cropland <sup>1</sup>	Perennial Cropland		Set-Aside Cropland	Total Cropland
		Orchard	Vineyard		
1985	5,036	104	154	187	5,480
BY	5,042	100	149	182	5,473
1986	5,044	99	147	181	5,471
1987	5,048	97	145	180	5,469
1988	5,050	95	142	180	5,467
1989	5,052	94	140	176	5,463
1990	5,054	95	139	172	5,460
1991	5,009	95	134	195	5,434
1992	4,963	96	130	218	5,407
1993	4,918	96	126	261	5,401
1994	4,873	96	122	306	5,397
1995	4,828	96	118	348	5,390
1996	4,782	96	114	390	5,382
1997	4,737	97	109	430	5,373
1998	4,692	97	105	471	5,365
1999	4,647	97	101	510	5,354
2000	4,601	97	97	548	5,344
2001	4,582	98	93	557	5,329
2002	4,562	97	92	562	5,313
2003	4,542	97	91	572	5,301
2004	4,522	96	90	580	5,288
2005	4,503	96	88	599	5,285
2006	4,483	95	87	606	5,271
2007	4,463	95	86	606	5,250
2008	4,443	95	85	616	5,239
2009	4,423	94	84	628	5,230
2010	4,404	94	83	643	5,223

<sup>1</sup>Kitchen gardens included.

The area of Cropland category is based on the HCSO's annual land-use statistics, revised by the HCSO's and the HMS's experts to avoid inconsistencies (Annex A3.4).

The CO<sub>2</sub> removals and emissions from living biomass, dead organic matter, mineral soils and agricultural lime application are reported under this category. (Organic soils are not under cultivation in Hungary.) N<sub>2</sub>O emissions from disturbances associated with land-use conversion to Cropland are reported in CRF table 5(III). CH<sub>4</sub> and N<sub>2</sub>O Emissions from Wildfires are also included. The net CO<sub>2</sub> removal from Cropland was 948 Gg in 2010, the CH<sub>4</sub> and N<sub>2</sub>O and emission were 0.01 and 0.08 Gg respectively. Figure 7.7 shows the trends in emissions and removals from Croplands over the period 1985-2010.



**Figure 7.7. Emissions/Removals from 5.B category Cropland 1985-2010**

Note: Non-CO<sub>2</sub> emissions from biomass burning and N<sub>2</sub>O emissions from land disturbance included in biomass and mineral soils, respectively.

## 7.4.2 Cropland remaining Cropland

This category comprises emissions and removals from the change of management practices (including the effects of the abandonment) on croplands.

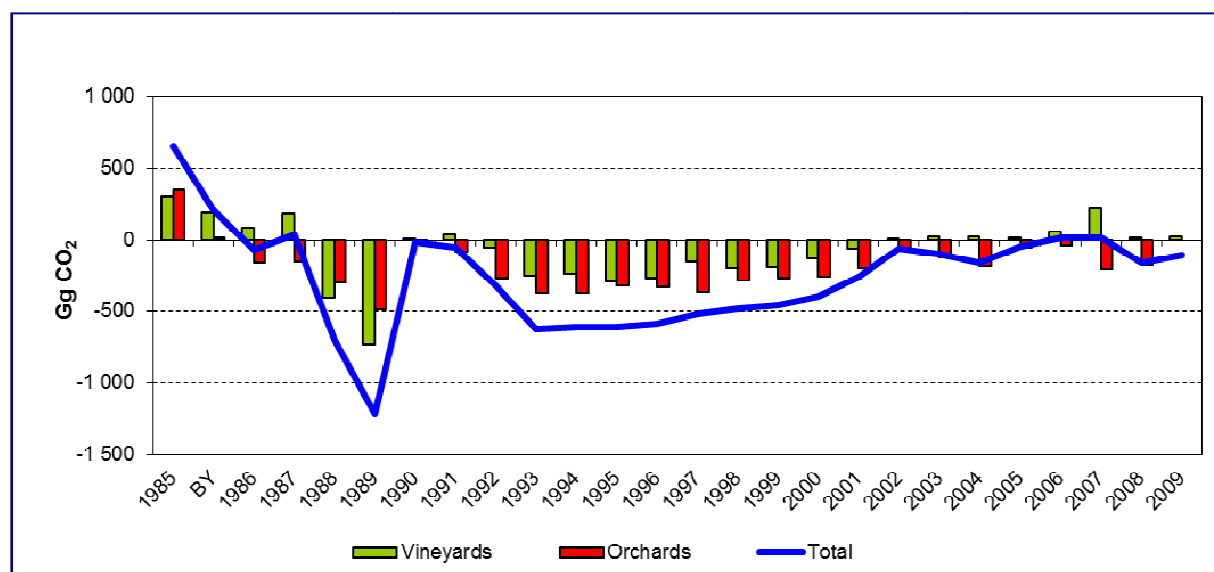
### 7.4.2.1 Carbon stock change in living biomass

In accordance with the GPG for LULUCF (IPCC, 2003) the change in biomass is only estimated for perennial woody crops, because there is no net accumulation of biomass of annual crops.

In 2010 Cropland living woody biomass was a sink of 26 Gg CO<sub>2</sub> due to the carbon accumulation in orchard. The living woody biomass comprises the orchards and vineyards in Hungary. There is a permanent vineyard abandonment system in the EU; therefore vineyard removal is subsidized in Hungary similarly to other EU member states.

Vineyards were a source of 110 GgCO<sub>2</sub>, while orchards were a sink of 136 GgCO<sub>2</sub> in 2010. Both of the area decreased in 2010.

The trend in emission from Cropland woody biomass is changeable over the time series as shown in Figure 7.8.



**Figure 7.8.** Trends in emissions/removals from Cropland living (woody) biomass in the category 5.B.1 for 1985-2010

#### 7.4.2.1.1 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 ( $\Delta CC_{LB}$ ) was estimated from the annual rates of biomass gain and loss provided by the Tier 1 methodology of GPG for LULUCF (IPCC, 2003). Similarly 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:

$\Delta CC_{LB}$  = annual change in carbon stocks in living biomass on Cropland

$\Delta C_G$  = annual increase in carbon stocks due to biomass growth,  $\text{t C yr}^{-1}$

$\Delta C_L$  = annual decrease in carbon stocks due to biomass loss,  $\text{t C yr}^{-1}$

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

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

Where:

$A_G$  = area of perennial woody cropland (orchard and vineyard in Hungary)

$G$  = IPCC default value for perennial crops carbon accumulation rate is  $2.1 \text{ t C ha}^{-1} \text{ yr}^{-1}$

$A_L$  = area of cropland on which perennial woody crops (orchard and vineyard) are removed

$L$  = IPCC default value for perennial crops carbon loss,  $63 \text{ t C ha}^{-1} \text{ yr}^{-1}$

#### 7.4.2.1.2 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 the HCSO. The HCSO's records the orchard and vineyards area divided 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 statistics for private farms which is shown in Annex A3.4. The area of removed/orchards and vineyards in 'cropland remaining cropland' were determined as the difference between the total removed orchard/vineyard area and the total removal due to land-use change. The estimation of areas of orchard/vineyards removals due to land-use change based on the  $HLC\_change_{1985-1990}$  and  $CLC\_change$  data sets.

#### 7.4.2.2 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 economic 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 unfavorable 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<sub>2</sub>-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).

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<sup>-1</sup>

$\Delta C_{CCMineral}$  = annual change in carbon stocks in mineral soils, tonnes C yr<sup>-1</sup>

$\Delta C_{CCOrganic}$  = annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr<sup>-1</sup>

$\Delta C_{CCLime}$  = annual C emissions from agricultural lime application, tonnes C yr<sup>-1</sup>.

Taking these components into account, the total annual soil carbon stock change in the Cropland category in Hungary in 2009 was 139.4-3.1=136.3Gg C.

##### 7.4.2.2.1 Mineral soils

In 2010 mineral soils in category 5.B.1 Cropland remaining Cropland was a sink of 312 GgC. Over the period 1965-1998 the carbon stock of cropland is considered to be static, because there was no significant change in management practices. The full tillage of croplands was the only applied cultivation system until the end of 1990ies, but from 1998 the conventional soil cultivation was prospectively replaced by conservation tillage methods. The no-till method is assumed to be applied since 2000. The new, conservation tillage methods resulted in a miner increase in the carbon stock of croplands in Hungary from 1998 (See Figure 7.7).



#### 7.4.2.2.1.1 Choice of method

For calculation of carbon stock change in mineral soils the IPCC Tier 1 method the Equation 3.3.4. B of the GPG for LULUCF (IPCC, 2003) was used as follows:

$$\Delta C_{CCMineral} = (SOC_0 - SOC_{0-T}) \cdot A / T$$

$$SOC = (\sum_{csi} (A_{csi} \cdot SOC_{ref} \cdot F_{LU} \cdot F_{MG} \cdot F_I)) / \sum_{csi} A_{csi}$$

Where :

$\Delta C_{CCMineral}$  = annual change in carbon stock in mineral soils

$SOC_0$  = average soil organic carbon stock in the inventory year

$SOC_{0-T}$  = average soil organic carbon stock T years prior to the inventory

A = land area

T = inventory time period (the 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

c represents the climate zones, s the soil types and i the set of major management system.

In Hungary the soil organic carbon stock can be estimated aggregately for the different land-use types, therefore the average carbon stocks were used for the calculation. The average carbon stock for the different land-use categories were determined from the categorization by climate zones, soil types and management practices.

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.

The estimated average carbon stocks for Cropland for the period 1965-2010 are shown in Table A3-8 and A3-9 of Annex A3.4. (Although the land-use transition is taken into account due to lack of information before 1985. The average carbon stocks are estimated from 1965.)

#### 7.4.2.2.1.2 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.

The area data stratified by climate, soil type and management practices are provided in Table A3-8 and A3-9 of Annex A3.4.

#### 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 "Improvement and international correlation of the Hungarian soil classification system", 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 2009 (Table 7.15).

**Table 7.15.** *Classification of the croplands in Hungary by soil type in proportion to the total land*

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 utilized 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°C and the annual precipitation is less than the evapotranspiration, and Warm Temperate Dry (WTED), where the mean annual temperature (MAT) is above 10°C 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 7.16).

**Table 7.16.** *Classification of the croplands in Hungary by climate in proportion to the total land*

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

Soil cultivation technologies were first surveyed in Hungary in the course of the General Agricultural Census, 2010 (Table 7.17). For the former submission expert judgment was applied to estimate the area of the different tillage methods. Therefore the data of this survey has resulted in a substantial improvement of the emission estimation for mineral soils in Cropland.

**Table 7.17.** *Proportion of the area of soil cultivation technologies in 2010*

Soil cultivation technology	Proportion of cropland area
Full tillage	87.7%
Reduced tillage	11.11%
no-till	1.16%

In accordance with the expert judgment for the former submission, the full tillage of croplands was assumed to be the only applied cultivation system until the end of 1990ies, prospectively replaced by reduced tillage from 1998.

The no-till was not taken into account in the previous emission estimations, but the Central Agricultural Census, 2010 indicated, that this technology has been also observable in Hungary. It was assumed for the estimation that the no-till method is applied since 2000.

For the periods 1998-2010 the proportion of the different soil cultivation technologies were calculated by linear interpolation.

#### Input

To choose the input factors (Table 7.18) 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, the proportion of the area of medium input had increased from 40 per cent in 1985 to 51 per cent in 2010, while the area of low input had decreased from 55 per cent to 44per cent in 2010.

**Table 7.18.** *Classification of the croplands in Hungary by input in proportion to the total land in 2010*

Input category	Proportion of total cropland area (%)
Low	44
Medium	51
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.

#### 7.4.2.2.1.3 Choice of stock change and emission/removal factors

For the reference carbon stocks ( $SOC_{REF}$ ) the IPCC default values were applied in accordance with the Table 3.3.3 of the GPG for LULUCF (IPCC, 2003). The reference carbon stocks ( $SOC_{REF}$ ) used in the Hungarian inventory are listed in Table 7.19. Taking the recent practice of soil cultivation and crop production into consideration the categorization 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 7.19, Table 7.20, Table 7.21 Table 7.22.

**Table 7.19.** Soil type coverage and soil organic carbon stocks ( $SOC_{REF}$ ) in Hungary (tC ha per ha)

Climate zone	High activity clay soils	Low activity clay soils	Sandy soils	Aquic soils
Cold temperate, dry	50	33	34	87
Warm temperate, dry	38	24	19	88

**Table 7.20.** Land use factors ( $F_{LU}$ )

Land use level	Factors
Long term cultivated	0.82
Set aside < 20 yrs	0.93

**Table 7.21.** Management factors ( $F_{MG}$ )

Land use	Management regime	Factors
Cropland	full till	1.00
	reduced till	1.03
	no-till	1.10

**Table 7.22.** Input factors ( $F_I$ )

Land use	Input of organic matter	Factors
Cropland	low	0.92
	medium	1.00
	high- with no manure	1.07

#### 7.4.2.2.2 Liming

Liming also showed a decreasing tendency in Hungary in the last decade. Emissions from liming accounted for 6.85 Gg CO<sub>2</sub> in 2010.

##### 7.4.2.2.2.1 Choice of method and emission factors

The Tier 1 method and default emission factor of 0.12 provided by the GPG for LULUCF

(IPCC, 2003) were used to estimate the emissions from carbonate containing lime. Emissions from dolomite use were estimated using the emission factor of 0.13 based on the stoichiometric formula of dolomite, following a recommendation of the centralized review of the 2011 submission.

#### 7.4.2.2.2.2 *Choice of activity data*

Data on the amounts of agricultural lime application are not available in Hungary, therefore in order to calculate CO<sub>2</sub> emissions from application of carbonate containing lime (calcic limestone), or dolomite (CaMg(CO<sub>3</sub>)<sub>2</sub>) to agricultural soils, we had to determine the amount of carbonate containing chemical amendments used for soil reclamation in the reporting year.

The total area of the reclaimed soils was available from the statistical database of the Agricultural Economics Research Institute; (website: [www.akii.hu](http://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 farms). In the data bases the reclaimed soils include acidic, salt affected and sandy soil categories. The last category, i.e. sandy soils was not taken into account as a source of CO<sub>2</sub> emissions, as high organic matter containing amendments and not carbonate containing materials are added to these soils to increase their fertility,.

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 of the Central Agricultural Office 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.

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 judgment. According to this judgment 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 were estimated to be reclaimed with limestone or other carbonate containing material.

Data on the amounts of the limestone and dolomite applied to soils for 2010 were obtained from the National Plant- and Soil Protection Directorates of the Central Agricultural Office. The CAO has provided not only the area of the lime application but also the amounts of the lime stone and dolomite use since 2011.

#### 7.4.2.2.3 *Organic soils*

Emissions from organic soils in cropland are not reported, because organic soils are wetland soils in Hungary, and wetlands are ex-lege protected. Consequently, croplands cannot be found on organic soils in Hungary. The AGROTOPO, which is a digital soil map of Hungary, confirms the assumption applied in accordance with the legal legislation, because the soil map was superimposed on the CORINE land cover database, but this overlay combination did not delineate cropland areas on organic soils.

The research project on the development of country-specific reference carbon stocks for mineral soils has confirmed the assumption again, because none of the soil types of the sampling plots of the Hungarian Soil Monitoring System could have been classified as organic soil. Therefore 'NO' is reported for the carbon stock change in organic soils under 5.B.

### 7.4.3 Land converted to Cropland

#### 7.4.3.1 Forest Land converted to Cropland

See Chapter 7.3.3.

#### 7.4.3.2 Grassland converted to Cropland

##### 7.4.3.2.1 Carbon stock change in living biomass

In this category only the carbon stock change in living non-woody biomass is reported. It is assumed, that all plantation of vineyards and orchards was taken place in 'cropland remaining cropland'. The carbon stock change in living biomass in category 5.B.2.2 Grassland converted to Cropland amounted to 5.34 Gg C in 2010.

##### 7.4.3.2.1.1 Choice of methodology

The Equation 3.3.8 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LCLB} = A_{\text{Conversion}} \cdot (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

Where:

$\Delta C_{LCLB}$  = Carbon stock change in Cropland living biomass in land converted to Cropland category, tonnes C year<sup>-1</sup>

$A_{\text{Conversion}}$  = annual area of land converted to Cropland

$L_{\text{Conversion}}$  = Carbon stock change per area for the type of conversion when land is converted to Cropland tonnes C ha<sup>-1</sup>

$C_{\text{After}}$  = carbon stocks in living biomass after the conversion to Cropland tonnes C ha<sup>-1</sup>

$C_{\text{Before}}$  = carbon stocks in living biomass before the conversion to Cropland tonnes C ha<sup>-1</sup>

In accordance with the Tier 1 assumption the carbon stock of living biomass immediately after conversion was considered to be zero. ( $C_{\text{After}}=0$ )

##### 7.4.3.2.1.2 Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The proportion of 'grassland converted to annual croplands' to 'grassland converted to (annual and perennial) croplands' were determined from the land cover-change databases for the periods 1986-1992, 1992-2000 and 2000-2010. The calculated proportions are 98, 99 and 95 percent, respectively. The estimated activity data are presented in Table 7.23.

**Table 7.23. Activity data of carbon stock change in living biomass in category 5.B.2.2 (ha)**

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Areas of grassland converted to annual cropland	4,797	5,596	4,797	7,195	7,195	7,195	7,195	NO	NO	8,211	8,211	8,211	8,211	8,211
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Areas of grassland converted to annual cropland	8,211	8,211	8,211	2,838	2,838	2,838	2,838	2,838	2,838	2,838	2,838	2,838	2,838	

For years 1991 and 1992 the area of 'grassland converted to cropland' were assumed to be 'NO', because the total area of croplands decreased significantly in these years.

#### 7.4.3.2.1.3 Choice of emission factors

In reference to  $\Delta C_{\text{Growth}}$  the IPCC default value of 5 tonnes per hectare suggested for annual crops was accounted (Table 3.3.8 of the GPG for LULUCF). It is important to note that only areas converted to annual crops is reported in this category. Carbon stock change in perennial biomass of Croplands is reported in 5.B.1 Cropland remaining Cropland category.

For carbon stocks of before conversion ( $C_{\text{Before}}$ ) the default carbon stocks values provided in Table 3.3.7 and Table 3.4.2 of GPG for LULUCF (IPCC, 2003) were applied.

The default values in Table 3.4.2 are provided for the dry matter of above ground biomass, therefore the carbon stocks were calculated as follows, in accordance with the Equation 3.4.6 of GPG for LULUCF (IPCC, 2003):

$$C_{\text{Before}} = CF \cdot (B_{\text{AG}} + B_{\text{BG}})$$

$$B_{\text{BG}} = B_{\text{AG}} \cdot (1 + R)$$

Where:

CF= carbon fraction of dry matter, tonnes C (tonnes d.m.)<sup>-1</sup>

$B_{\text{AG}}$ = aboveground biomass, tonnes d.m. ha<sup>-1</sup>

$B_{\text{BG}}$ = belowground biomass, tonnes d.m. ha<sup>-1</sup>

R= root to shoot ratio

For the CF the IPCC default value 0.5 was applied. While for the R the IPCC default value provided in Table 3.4.3 of GPG for LULUCF (IPCC, 2003) for semiarid grasslands was taken into account (R=2.8). Hungarian grasslands situated in cold dry and warm dry climate zones, therefore in accordance with the Table 3.4.2 of the GPG for LULUCF (IPCC, 2003) the aboveground perennial biomass ( $B_{\text{AG}}$ ) is 1.7 tonnes d.m. ha<sup>-1</sup> in the cold dry climate zone and 1.6 tonnes d.m. ha<sup>-1</sup> in the warm climate zone. The total above ground biomass was calculated in the proportion of distribution of grasslands by climate zones. (It was assumed that 41 per cent of converted grasslands situated in cold dry and 59 per cent in warm dry climate zone.

According to the calculation as described above in Hungary

$-0.5 \cdot (0.41 \cdot 1.7 + 0.59 \cdot 1.6) \cdot (1 + 2.8) + 5 = 1.88 \text{ tC ha}^{-1}$  is the carbon stock change in the living non-woody biomass on grasslands converted to annual cropland.



#### 7.4.3.2.2 Carbon stock change in soils

##### 7.4.3.2.2.1 Mineral soils

Carbon stock change in mineral soils in category 5.B.2.2 Grassland converted to Cropland amounted to -61.8 Gg C in 2010.

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 above, but in case of land-use conversion, the  $SOC_0$  is the *average* soil organic carbon stock of the land-use category in the inventory year (Cropland) and  $SOC_{0-T}$  is the *average* soil organic carbon stocks for the former land-use category, T years prior to the inventory year (Grassland), and A is the converted area.

The calculated average carbon stocks of mineral soils in Cropland and Grassland are provided in Table A3-8 - A3-11 in Annex A3.4.

#### 7.4.3.3 Wetlands converted to Cropland

This land-use change is not occurring in Hungary.

#### 7.4.3.4 Settlements converted to Cropland

Land cover change databases indicate rather small settlements areas, which are converted to croplands. These areas are biological re-cultivation of abandoned surface mines. The area of this land conversion ranges between 1 and 28 ha per year in the inventory period, peaked between 1990 and 2000 as a result of the economic and political transition to the market economy. In the latter years on average one hectare settlement area is converted to cropland per year. The biological re-cultivation probably results in an increase in the carbon stocks, therefore the omission of this category can be considered as a conservative approach. On the other hand the omitted removal is negligible because of the rather small area therefore 'NE' is reported for the carbon stock change in the category 5.B.2.4.

#### 7.4.3.5 Other Land converted to Cropland

This land-use change is not occurring in Hungary.

#### 7.4.3.6 Liming

No liming was reported for this sub-category.

#### 7.4.3.7 Organic soils

In Hungary all the croplands can be found on mineral soils, no organic soils are under cultivation. Therefore 'NO' is reported for the carbon stock change in organic soils under 5.B. For more details see 7.4.2.2.3.

### 7.4.4 Uncertainties and time-series consistency

Uncertainty estimates for the LULUCF sector were calculated using the Tier 1, 'simple propagation of error' method provided by the GPG for LULUCF (IPCC, 2003).

The uncertainties of the area/activity data are based on expert judgement. The uncertainty values of the stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003). The combined uncertainty of the sub-category 5(IV) had to be estimated because the uncertainties of neither the emission factors nor the activity data were available. The results of uncertainty assessment are shown in Table 7.24 and Table 7.25.

**Table 7.24.** *Uncertainties in CO<sub>2</sub> removals from 5.B.1 Cropland remaining Cropland by carbon pools*

Source category	CO <sub>2</sub> emissions	Uncertainty		
		Area (A) u(AD <sub>i</sub> )	Stock Change/Emission factor(s) u(EF <sub>i</sub> )	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
	Gg	±%		
Biomass in 5.B.1				
Gains	-1,359	6	75	75
Losses	1,333	30	75	81
Mineral Soil in 5.B.1	-1,146	25	39	46
<b>Overall uncertainty</b>	<b>-1, 172</b>	<b>0</b>	<b>134</b>	<b>134</b>
Liming	7	0	25	25
<b>Overall uncertainty (Liming incl.)</b>	<b>-1, 165</b>	<b>0</b>	<b>135</b>	<b>135</b>

**Table 7.25.** *Uncertainties in CO<sub>2</sub> removals from 5.B.2 Land converted to Cropland by carbon pools*

Source category	CO <sub>2</sub> emissions	Uncertainty		
		Area (A) u(AD <sub>i</sub> )	Stock Change/Emission factor(s) u(EF <sub>i</sub> )	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
	Gg	±%		
Biomass in 5.B.2				
Biomass in 5.B.2.1	7	25	45	52
Biomass in 5.B.2.2				
Gains	-52	30	75	81
Losses	32	30	75	81
DOM in 5.B.2.1	1	14	14	20
Mineral Soils in 5.B.2				
Mineral Soil in 5.B.2.1	2	4	91	91
Mineral Soil in 5.B.2.2	227	30	39	49
<b>Overall uncertainty</b>	<b>214</b>	<b>0</b>	<b>51</b>	<b>51</b>

#### 7.4.5 Category-specific recalculations

Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were divided according to the appropriate land-use change categories and allocated from the 5.B.1 Cropland remaining Cropland into the 5.A.2.1 Cropland converted to Forest Land, 5.C.2.2 Cropland converted to Grassland and 5.E.2.2 Cropland converted to Settlements categories for the whole time-series. Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting changes in the reallocated emissions. The reallocations are shown in Table 7.26.

**Table 7.26.** *Revised allocation of losses in carbon stock of living biomass of orchards and vineyards (GgC)*

Year	Submission 2011	Submission 2012				
	5.B.1.1	Total	5.B.1.1	5.A.2.1	5.C.2.2	5.E.2.2
1985	-840	-840	-718	-46	-67	-8
BY	-660	-660	-577	-38	-38	-7
1986	-584	-584	-498	-33	-47	-6
1987	-557	-557	-516	-35	0	-6
1988	-347	-347	-307	-36	0	-3
1989	-208	-208	-162	-45	0	-2
1990	-533	-533	-487	-41	0	-5
1991	-556	-556	-468	-37	-44	-6
1992	-470	-470	-386	-41	-38	-5
1993	-400	-400	-296	-15	-82	-7
1994	-390	-390	-292	-11	-80	-6
1995	-388	-388	-284	-18	-80	-6
1996	-385	-385	-280	-20	-79	-6
1997	-404	-404	-292	-23	-83	-7
1998	-404	-404	-295	-20	-83	-7
1999	-408	-408	-292	-25	-84	-7
2000	-407	-407	-300	-26	-62	-18
2001	-428	-428	-328	-15	-65	-19
2002	-494	-494	-379	-18	-75	-22
2003	-472	-472	-367	-12	-72	-21
2004	-449	-449	-347	-13	-68	-20
2005	-470	-470	-375	-3	-71	-21
2006	-450	-503	-389	-15	-76	-23
2007	-435	-507	-384	-23	-77	-23
2008	-429	-432	-334	-13	-66	-19
2009	-443	-447	-346	-13	-68	-20

Emissions from dolomite use were revised as an outcome of the centralized review of 2011 submission. The emission factor based on the stoichiometric formula of dolomite was used instead of the emission factor provided by the GPG for LULUCF (IPCC, 2003). The changes in emissions due to recalculation are negligible (Table 7.28).

The proportion of cropland and set-aside cropland was revised for the period 2000-2009, as a result of the General Agricultural Census, 2010. (Cropland area reported for 2010 by the HCSO is significantly lower than the area reported for the previous years. To ensure the time-series consistency, the area of cropland used was adjusted for the period 2000-2009, using linear interpolation between the reported areas for 2000 and 2010.) This recalculation resulted in changes in removal of mineral soils for the period 2000-2010.

In the course of the General Agricultural Census, 2010 the soil cultivation techniques were first surveyed. The new activity data relating to the soil cultivation techniques resulted in changes in the emissions of mineral soils in the 5.B.1 Cropland remaining Cropland, 5.B.2.1 Forest Land converted to Cropland, 5.C.2.1 Grassland converted to Cropland for the period 1998-2009. The net changes in the emissions from mineral soils due to last two recalculations ranged from -2 Gg CO<sub>2</sub> to -288 Gg CO<sub>2</sub> (Table 7.28).

Recalculations reduced emissions and increased removals for the whole time-series. The overall effect of the recalculations is a decrease of 83% in emissions in BY, and an increase of 250% in removals in 2009 (Table 7.27). (The reduction is an average of 30 per cent, in the early years, while significantly higher in the latter ones.) The main driver behind this reduction is the allocation of carbon stock change in living (woody) biomass due to land-use change conversions into the appropriate land-use change categories (Table 7.26). The revised estimation of carbon stock change in mineral soils also contributed to the increased removals for the period 1998-2009, resulting high percentage changes for the latter years.

It has to be noted, that emissions reported in the submission 2011 for the period 2002-2006 were low, therefore the recalculations resulted in higher percentage changes for this period than for the other years.

**Table 7.27. Recalculation of CO<sub>2</sub> emissions from 5.B Cropland 1985-2009**

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2011 [Gg CO <sub>2</sub> ]	664	1 210	378	404	-336	-817	461	429	
Submission 2012 [Gg CO <sub>2</sub> ]	362	765	65	257	-476	-986	293	111	
Difference [Gg CO <sub>2</sub> ]	-302	-446	-313	-147	-140	-169	-167	-318	
Percentage change	-83%	-37%	-83%	-36%	42%	21%	-36%	-74%	
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Submission 2011 [Gg CO <sub>2</sub> ]	86	-298	-319	-345	-347	-278	-341	-352	-340
Submission 2012 [Gg CO <sub>2</sub> ]	-219	-679	-675	-724	-731	-689	-744	-783	-739
Difference [Gg CO <sub>2</sub> ]	-305	-381	-357	-379	-384	-410	-403	-431	-399
Percentage change	-355%	128%	112%	110%	111%	147%	118%	123%	118%
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2011 [Gg CO <sub>2</sub> ]	-183	86	23	-49	25	-42	-112	-221	-258
Submission 2012 [Gg CO <sub>2</sub> ]	-589	-409	-468	-560	-493	-468	-532	-833	-904
Difference [Gg CO <sub>2</sub> ]	-406	-495	-491	-511	-518	-426	-420	-612	-645
Percentage change	222%	-576%	-2166%	1039%	-2061%	1014%	375%	277%	250%

**Table 7.28.** Recalculation of CO<sub>2</sub> emissions/removals from 5.B Cropland by source categories (Gg CO<sub>2</sub>)

	BY	1990	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<b>5.B.1 Living biomass/Losses</b>														
Submission 2011	2421	1956	1422	1482	1491	1569	1812	1730	1648	1725	1651	1595	1572	1624
Submission 2012	2117	1785	1042	1081	1101	1204	1390	1344	1274	1376	1426	1407	1224	1268
Difference	-304	-171	-380	-401	-390	-365	-422	-385	-374	-349	-226	-188	-348	-357
<b>5.B.1 Mineral soils</b>														
Submission 2011	38	88	-104	-227	-325	-316	-303	-294	-285	-303	-306	-309	-407	-511
Submission 2012	38	88	-104	-228	-335	-358	-377	-400	-423	-472	-507	-542	-667	-800
Difference	0	0	0	-2	-10	-42	-74	-106	-138	-169	-201	-232	-261	-288
<b>5.B Liming</b>														
Submission 2011	141	238	33	4	37	41	35	45	27	31	32	14	10	11
Submission 2012	144	242	34	4	37	42	35	46	28	31	33	14	10	11
Difference	2	4	1	0	1	1	1	1	0	0	0	0	0	0
<b>Total net CO<sub>2</sub></b>														
Submission 2011	664	461	-345	-341	-340	-183	86	23	-49	25	-42	-112	-221	-258
Submission 2012	362	293	-724	-744	-739	-589	-409	-468	-560	-493	-468	-532	-833	-904
Difference	-302	-167	-379	-403	-399	-406	-495	-491	-511	-518	-426	-420	-612	-645

#### 7.4.6 Category-specific planned improvements

Research program on the processing of data of the Hungarian Soil Monitoring System to develop country-specific values for the reference carbon stock of mineral soils has been finished. Emissions relating to mineral soils are planned to be revised, applying the new research results.

Further refinement of the uncertainty assessment and the development of Monte Carlo approaches are also planned for the next inventory cycle.

## 7.5 Grassland (CRF sector 5.C)

### 7.5.1 Description of category

Although nowadays the area of grasslands is accounting for 13 percent of the official area of Hungary, the area of grasslands utilized for agricultural purposes (meadows and pastures) decreased considerably during the last three decades. While 1,246,400 ha Grassland were utilized in 1985, only 762,600 ha remained by 2010 as shown in Table 7.29. From the base year the decrease of meadows and pastures areas were 38%.

**Table 7.29. Grassland areas 1985-2010 (ha)**

Year	Area		
	Grassland	Set-Aside Grassland	Total Grassland
1985	1,246,400	39,997	1,286,397
BY	1,234,133	47,070	1,281,204
1986	1,233,700	50,152	1,283,852
1987	1,222,300	51,061	1,273,361
1988	1,209,900	52,957	1,262,857
1989	1,197,300	54,382	1,251,682
1990	1,185,600	55,174	1,240,774
1991	1,172,160	81,366	1,253,526
1992	1,158,720	107,250	1,265,970
1993	1,145,280	117,132	1,262,412
1994	1,131,840	127,336	1,259,176
1995	1,118,400	136,983	1,255,383
1996	1,104,960	146,478	1,251,438
1997	1,091,520	155,712	1,247,232
1998	1,078,080	165,150	1,243,230
1999	1,064,640	174,122	1,238,762
2000	1,051,200	182,989	1,234,189
2001	1,022,340	207,428	1,229,768
2002	993,480	231,462	1,224,942
2003	964,620	256,347	1,220,967
2004	935,760	281,111	1,216,871
2005	906,900	307,530	1,214,430
2006	878,040	331,978	1,210,018
2007	849,180	357,898	1,207,078
2008	820,320	384,107	1,204,427
2009	791,460	410,330	1,201,790
2010	762,600	436,821	1,199,421
<b>Trend BY-2010</b>	<b>-38%</b>	<b>828%</b>	<b>-6%</b>

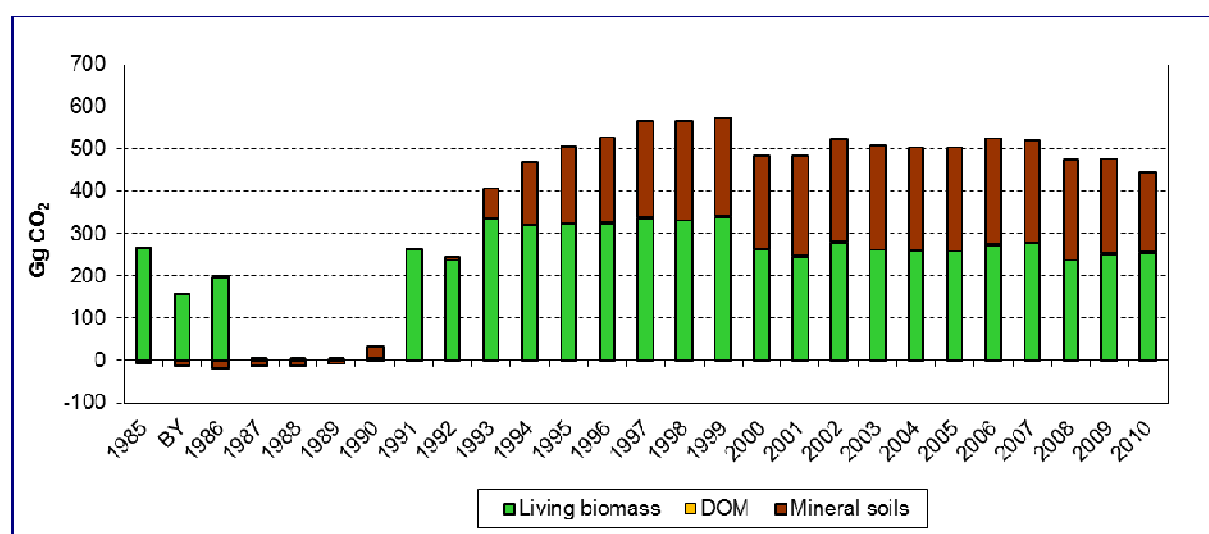
Contrary to this trend, the change in the number of livestock of grazing animals (mainly cattle, sheep and geese as the livestock of horses, water buffalos and goats were not so considerable from the 1970ies) was something different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million 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 trend in emissions/removals from the Grassland category can be explained by the above mentioned changes (Figure 7.9).

It should be noted, that the HCSO records grasslands which are used for agricultural purposes. Abandoned pastures and natural grasslands are reported as 'unproductive areas' in this statistics therefore the annual areas of the set-aside grasslands were estimated from the compilation of the HCSO's land-use statistics and CLC-change databases.

CO<sub>2</sub> removals and emissions from living biomass due to land-use conversions and mineral soils are reported under this category. (Organic soils are not used for agricultural purposes in Hungary.) The CO<sub>2</sub> emissions from category 5.C Grassland was 444 Gg in 2010.



**Figure 7.9.** Trend in emissions/removals from category 5.C Grassland 1985-2010

## 7.5.2 Grassland remaining Grassland

This category comprises emissions and removals from the change of management practices (including the effects of the abandonment) on grasslands.

### 7.5.2.1 Carbon stock change in living biomass

In Hungary grassland management practices can be considered static, so according to Tier 1 method, no change in living biomass carbon stock was estimated. In CRF table 5.C.1 'NO' are reported.

### 7.5.2.2 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<sub>2</sub>-emission from grasslands (Nagy et al., 2007, Zsembeli et al. 2006).

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

$$\Delta C_{GGS\text{Soils}} = \Delta C_{GGS\text{Mineral}} - \Delta C_{GGS\text{Organic}} - \Delta C_{GGS\text{Lime}}$$

Where:

$\Delta C_{GGS\text{Soils}}$  = annual change in carbon stocks in soils in Grassland remaining Grassland,



tonnes C yr<sup>-1</sup>

$\Delta C_{GGMineral}$  = annual change in carbon stocks in mineral soils, tonnes C yr<sup>-1</sup>

$\Delta C_{GGOrganic}$  = annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr<sup>-1</sup>

$\Delta C_{GGLime}$  = annual C emissions from agricultural lime application, tonnes C yr<sup>-1</sup>.

$\Delta C_{GGOrganic}$ =0, because grasslands on organic soils not used for agricultural purposes in Hungary.

$\Delta C_{GGLime}$ =0, because lime application on grasslands are negligible in Hungary.

Taking these components into account, the total annual soil carbon stock change in the category 5.C.1 Grassland remaining Grassland in Hungary amounted to 405 Gg CO<sub>2</sub> in 2010.

#### 7.5.2.2.1 Mineral soils

In 2010 mineral soils in category 5.B.1 Grassland remaining Grassland was a source of 405 Gg CO<sub>2</sub>.

##### 7.5.2.2.1.1 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. The calculated average carbon stocks are provided in Table A3-10 and A3-11 in Annex A3-4.

##### 7.5.2.2.1.2 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 Chapter 7.4.2.2.1. Grasslands 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 (Table 7.30).

**Table 7.30.** Classification of the grasslands in Hungary by soil type in proportion to the total land

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 utilized 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 standardized and expressed in livestock units. The spatial distribution of quality, utilization, 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 characterize 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 fertilization and irrigation were taken into consideration. Beyond the decrease of the number of livestock, the area of fertilized 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 are utilized by grazing. The management, the treatment of grasslands is limited to their grazing and cutting.

**Table 7.31.** *Classification of the grasslands in Hungary by management and input in proportion to the total land in 2010*

Management	Input	Proportion of total grassland area (%)
non-degraded	-	99.6
improved	medium	0.4

#### 7.5.2.2.1.3 Choice of stock change and emission factors

The categorization is partly based on expert judgment 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 can be followed knowing the extent of fertilization and irrigation of grasslands. The categorization of the grasslands of Hungary has been made regarding the climate, soil type, management and input.

The coverage of soil type and the applied soil organic carbon stocks was the same as that summarized in Table 7.19 in Chapter 7.4.2.2.1.3. The Land-use factor ( $F_{LU}$ ) was 1.0 for all grasslands, according to the GPG for LULUCF (IPCC 2003). The management factors ( $F_{MG}$ ) are shown in Table 7.32. The level of input ( $F_I$ ) was assumed to be 1.0 for the improved grassland as well as nominally managed grassland.

**Table 7.32.** *Management factors ( $F_{MG}$ )*

Land use	Management regime	Factors
Grassland	Nominally managed (non-degraded)	1.00
	Improved	1.14

#### 7.5.2.2.2 Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO<sub>2</sub> emissions, therefore it is reported as 'NO' in CRF table.

#### 7.5.2.2.2.1 Organic soils

In Hungary no organic soils are under agricultural grassland management therefore it is reported as 'NO' in CRF table.

### 7.5.3 Land converted to Grass Land

#### 7.5.3.1 Forest Land converted to Grassland

See Chapter 7.3.3.

#### 7.5.3.2 Cropland converted to Grassland

##### 7.5.3.2.1 Carbon stock change in living biomass

In this category carbon stock change in living biomass of annual and perennial croplands converted to grasslands are reported.

The carbon stock change in living biomass in category 5.C.2.2 Cropland converted to Grassland amounted to -68 Gg C in 2010.

##### 7.5.3.2.1.1 Choice of methodology

Equation 3.3.8 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LGLB} = A_{\text{Conversion}} \cdot (L_{\text{Conversion}} + \Delta C_{\text{Growth}})$$

$$L_{\text{Conversion}} = C_{\text{After}} - C_{\text{Before}}$$

Where:

$\Delta C_{LGLB}$  = Carbon stock change in living biomass due to land-use conversion to Grassland, tonnes C year<sup>-1</sup>

$A_{\text{Conversion}}$  = annual area of land converted to Grassland

$L_{\text{Conversion}}$  = Carbon stock change per area for the type of conversion when land is converted to Grassland tonnes C ha<sup>-1</sup>

$C_{\text{After}}$  = carbon stocks in living biomass after the conversion to Grassland, tonnes C ha<sup>-1</sup>

$C_{\text{Before}}$  = carbon stocks in living biomass before the conversion to Grassland, tonnes C ha<sup>-1</sup>

##### 7.5.3.2.1.2 Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period is not taken into account. The estimation of the perennial cropland converted to grassland area is based on the HCSO's removal statistics on vineyard and orchard compared with the HLC-Changes<sub>1985-1990</sub> and CORINE Land Cover-change databases. These land cover-change databases indicated that 8, 20.5 and 15.2 percent of the vineyard and orchard removal was taken place on areas converted to grassland. The annual cropland area was calculated as the difference between the 'total cropland converted to grassland' and the 'perennial cropland converted to grassland' area. The estimated activity data are presented in Table 7.33.

**Table 7.33.** Activity data for carbon stock change in living biomass in category 5.C.2.2

Year	Area (ha)			
	Annual cropland converted to grassland	Vineyard converted to Grassland	Orchard converted to Grassland	Total cropland converted to grassland
1985	4,271	616	450	5,338
BY	2,720	536	302	3,558
1986	4,596	501	240	5,338
1987	NO	NO	NO	NO
1988	NO	NO	NO	NO
1989	NO	NO	NO	NO
1990	NO	NO	NO	NO
1991	15,307	448	258	16,013
1992	15,416	407	190	16,013
1993	5,404	868	436	6,707
1994	5,436	834	437	6,707
1995	5,443	756	508	6,707
1996	5,451	753	503	6,707
1997	5,391	853	463	6,707
1998	5,390	758	560	6,707
1999	5,377	747	584	6,707
2000	5,726	555	426	6,707
2001	816	561	471	1,847
2002	656	616	576	1,847
2003	710	612	526	1,847
2004	764	608	475	1,847
2005	713	571	563	1,847
2006	636	623	589	1,847
2007	624	747	476	1,847
2008	807	557	484	1,847
2009	771	561	515	1,847
2010	729	617	502	1,847

In the period 1987-1990 the area of total grassland is decreasing significantly, therefore 'cropland converted to grassland' conversions were assumed to be 'NO'.

#### 7.5.3.2.1.3 Choice of emission factors

In accordance with the Tier 1 assumption, the carbon stock of living biomass was considered to be zero immediately after conversion. ( $C_{\text{After}}=0$ ).

For  $C_{\text{Before}}$  the IPCC default value, given for annual croplands were taken into account ( $5 \text{ tC ha}^{-1}$ ).

$\Delta C_{\text{Growth}}$  was calculated in accordance with the Tier 1 assumptions of the GPG for LULUCF (IPCC, 2003):

$$\Delta C_{\text{Growth}} = 0.5 \cdot (0.41 \cdot 6.5 + 0.59 \cdot 6.1)$$

The total above- and belowground biomass was calculated in the proportion of distribution of grasslands by climate zones using the IPCC default values provided in Table 3.4.9 of GPG for LULUCF (IPCC, 2003) for LULUCF. (It was assumed that 41 percent of converted grasslands situated in cold dry and 59 percent in warm dry climate zone.)

Coefficients relating to the woody biomass are similar to those were used in 5.B.1 Cropland

remaining Cropland.

#### 7.5.3.2.2 Carbon stock change in soils

##### 7.5.3.2.2.1 Mineral soils

Carbon stock change in mineral soils in category 5.C.2.2 Cropland converted to Grassland amounted to 59 Gg C in 2010.

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 7.4.2.2.1) but in case of land-use conversion the  $SOC_0$  is the *average* soil organic carbon stock of the land-use category in the inventory year (Cropland) and  $SOC_{0-T}$  is the *average* soil organic carbon stocks for the former land-use category (Grassland), T years prior to the inventory year, and A is the converted area.

Calculated average carbon stocks of mineral soils for Croplands and for Grassland are provided in Table A3-8A3-11 in Annex A3.4.

#### 7.5.3.3 Wetlands converted to Grassland

This land-use change is not occurring in Hungary.

#### 7.5.3.4 Settlements converted to Grassland

Land cover change databases indicate rather small settlements areas, which are converted to grasslands. These areas are biological re-cultivation of abandoned surface mines. The area of this land conversion ranges between 117 and 178 ha per year in the inventory period, peaked between 1990 and 2000 as a result of the economic and political transition to the market economy. The biological re-cultivation probably result an increase in the carbon stocks, therefore the omission of this category can be considered as a conservative approach, therefore 'NE' is reported for the carbon stock change in the category 5.C.2.4.

#### 7.5.3.5 Other Land converted to Grassland

This land-use change is not occurring in Hungary.

#### 7.5.3.6 Liming

In Hungary the amount of lime applied in grassland management practice is insignificant as a source of CO<sub>2</sub> emissions; therefore 'NO' is reported in CRF tables.

#### 7.5.3.7 Organic soils

In Hungary no organic soils are under agricultural grassland management therefore 'NO' is reported in CRF tables.

### 7.5.4 Uncertainties and time-series consistency

Uncertainty estimates for the LULUCF sector were calculated using the Tier 1, 'simple propagation of error' method provided by the GPG for LULUCF (IPCC, 2003).

The uncertainties of the area/activity data are based on expert judgment. The uncertainty values of the stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003). The results of the uncertainty assessment for the category 5.C are provided in Table 7.34 and Table 7.35.

**Table 7.34. Uncertainties in CO<sub>2</sub> removals from 5.C.1 Grassland remaining Grassland**

Source category	CO <sub>2</sub> emissions	Uncertainty		
		Area (A) u(AD <sub>i</sub> )	Stock Change/Emission factor(s) u(EF <sub>i</sub> )	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
	Gg	±%		
Mineral Soil	405	25	42	49
<b>Overall uncertainty</b>	<b>405</b>	<b>25</b>	<b>42</b>	<b>49</b>

**Table 7.35. Uncertainties in CO<sub>2</sub> emissions/removals from 5.C.2 Land converted to Grassland**

Source category	CO <sub>2</sub> Emissions	Uncertainty		
		Area (A) u(AD <sub>i</sub> )	Stock Change/Emission factor(s) u(EF <sub>i</sub> )	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
	Gg	±%		
<b>Biomass</b>	254	0	80	80
Biomass in 5.C.2.1	3	23	43	49
Biomass in 5.C.2.2	251	30	75	81
Gains	-21	30	75	81
Losses	272	30	75	81
<b>DOM</b>	1	14	14	20
DOM in 5.C.2.1	1	14	14	20
<b>Mineral Soils</b>	-216	0	52	52
Mineral Soil in 5.C.2.2	-216	30	42	52
<b>Overall uncertainty</b>	<b>38</b>	<b>0</b>	<b>593</b>	<b>593</b>

### 7.5.5 Category-specific recalculations

Areas under different management practices on Grassland (HAC soils in cold climate zone) were corrected for 2005, and 2009. This correction resulted in minor changes in the estimated carbon stock changes in mineral soils in 5.C.1 Grassland remaining Grassland.

The former land-use categories of afforested areas were corrected for the period 2007-2009 according to the NFI data. This change has effect on the estimated SA-Grassland areas, and as a consequence the emissions/removals of these categories differ from the previous ones.

Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were allocated from the 5.B.1 Cropland remaining Cropland into the 5.C.2.2 Cropland converted to Grassland. (Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting changes in the reallocated emissions. For more details see Table 7.26.

Recalculations resulted in a significant percentage change in the reported emissions (Table 7.36), especially in the early years of the time-series, because of the low emissions reported in submission 2011. The main driver of the change is the allocation of the emissions from vineyard and orchard removal due to land-use changes into the 5.C.2.2 (Table 7.37).

The inclusion of emissions from vineyard and orchard removal resulted in other changes in the reported emissions from 5.C.2.2. These changes are as follows:

- Emissions from 'annual cropland converted to grassland' have also been changed as a result of the refinement of the estimated area (see chapter 7.5.3.2.1.2). In the submissions up to 2011 the area of 'annual cropland converted to grassland' was estimated as a steady proportion of the total cropland converted to grassland area, but now it is changeable annually.
- Gains of the carbon stock in living biomass in 'vineyards and orchards converted to grassland' were omitted previously, but they are included now. (This recalculation is a consequence of the methodological difference between the estimation of emissions in a 'remaining' and the 'land converted to' categories.)

Changes in the emissions due to this recalculation are shown in Table 7.50.

The Table 7.36 shows the impact of recalculations for net CO<sub>2</sub> emissions removals. Recalculations for 5.C are large, due to allocation of orchard and vineyard removal due to land-use changes into the 5.C.2.2 category. All of the recalculations sum to give an overall impact on the emissions/removal from 5.C in the range 0-287 Gg CO<sub>2</sub>. Percentage changes are significant because of the low level of emissions/removals. The changes in the emissions are shown by carbon pools in Table Table 7.37.

**Table 7.36. Recalculation of CO<sub>2</sub> emissions from 5.C Grassland 1985-2009**

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2011 [Gg CO <sub>2</sub> ]	14	32	20	-11	-12	-5	32	109	
Submission 2012 [Gg CO <sub>2</sub> ]	143	260	179	-11	-12	-5	32	263	
Difference [Gg CO <sub>2</sub> ]	129	228	159	0	0	0	0	154	
Percentage change	928%	709%	784%	0%	0%	0%	0%	141%	
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Submission 2011 [Gg CO <sub>2</sub> ]	114	126	195	234	256	283	282	286	271
Submission 2012 [Gg CO <sub>2</sub> ]	245	407	469	507	527	566	566	573	484
Difference [Gg CO <sub>2</sub> ]	131	281	274	273	271	284	284	287	213
Percentage change	114%	223%	141%	116%	106%	100%	101%	100%	78%
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2011 [Gg CO <sub>2</sub> ]	264	268	266	273	259	265	258	248	246
Submission 2012 [Gg CO <sub>2</sub> ]	485	522	509	505	503	524	519	474	477
Difference [Gg CO <sub>2</sub> ]	221	255	243	232	244	259	262	226	231
Percentage change	84%	95%	92%	85%	94%	98%	102%	91%	94%



**Table 7.37. Recalculation of CO<sub>2</sub> emissions/removals from 5.C Grassland by carbon pools (Gg CO<sub>2</sub>)**

	BY	1985	1986	1991	1992	1993	1994	1995	2000	2005	2006	2007	2008	2009
<b>Emissions from Living Biomass under 5.C.2.2</b>														
Submission 2011	24	35	35	106	106	42	42	42	42	11	11	11	11	11
Submission 2012	153	263	194	260	237	323	316	315	255	254	270	273	234	242
Difference	129	228	159	154	131	281	274	273	213	243	259	261	223	230
<b>Emissions from Mineral Soils under 5.C</b>														
Submission 2011	-13	-6	-18	2	7	72	149	183	221	243	251	241	236	224
Submission 2012	-13	-6	-18	2	7	72	149	183	221	245	251	241	237	225
Difference	0	0	0	0	0	0	0	0	0	2	0	0	1	1
<b>Total net CO<sub>2</sub> Emissions from 5.C</b>														
Submission 2011	14	32	20	109	114	126	195	234	271	259	265	258	248	246
Submission 2012	143	260	179	263	245	407	469	507	484	503	524	519	474	477
Difference	129	228	159	154	131	281	274	273	213	244	259	262	226	231

### 7.5.6 Category-specific planned improvements

Research program on the processing of data of the Hungarian Soil Monitoring System to develop country-specific values for the reference carbon stock of mineral soils has been finished. Emissions relating to mineral soils are planned to be revised, applying the new research results.

Further refinement of the uncertainty assessment and the development of Monte Carlo approaches are planned for the next inventory cycle.

## 7.6 Wetlands (CRF sector 5.D)

Wetlands account for only 3 per cent of the total area of Hungary (Figure 7.1).

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 HLC-Changes<sub>1985-1990</sub>, CLC-Changes<sub>1990-2000</sub>, HLC-Changes<sub>2000-2006</sub> and CLC2006 databases. 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. The emissions of 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 ex lege in Hungary. Hungary is among the signatories of the Ramsar Convention, therefore the preservation and the sustainable uses of Wetlands are emphasized. In 2010, altogether 28 wetlands (233,927 ha) in Hungary had been included in the Ramsar List of Wetlands of International Importance.

### 7.6.1 Land converted to Wetlands

#### 7.6.1.1 Grassland converted to Wetlands

HLC\_change, CLC\_change<sub>1990-2000</sub>, and CLC\_change<sub>2000-2006</sub> datasets indicate 1014, 2928 and 1056 kha grasslands converted to wetlands in the period 1986-1992, 1992-2000 and 2000-2006, respectively. The CLC codes which were classified into this category are shown in Table 7.38:

**Table 7.38.** Areas classified as 'Grassland converted to Wetlands'

Period	CLC code	Explanation	Area (kha)
1992-2000			
	231-411	Pastures conversion to inland marshes	963
	231-512	Pastures conversion to water bodies	976
	321-411	Natural grasslands conversion to inland marshes	822
	321-512	Natural grasslands conversion to water bodies	167
<b>Total</b>			<b>2928</b>
2000-2006			
	231-512	Pastures conversion to water bodies	504
	321-411	Natural grasslands conversion to inland marshes	486
	321-512	Natural grasslands conversion to water bodies	66
<b>Total</b>			<b>1056</b>

The CLC code 411 represents inland marshes, which contains ‘*Low-lying land usually flooded in winter and more or less saturated by water all year round*’ in accordance with the CLC’s nomenclature. Therefore conversions listed above can be the results of the change in total annual precipitation. The analysis of the total annual precipitation supports this assumption, because the total annual precipitation before the acquisition date of the satellite images on which the CLC2000 data sets are based on highly exceeds the precipitation of the other years.

Emissions from these land-use conversions are not estimated and they are reported as ‘NE’, because these conversions are assumed to be the results of natural processes.

#### 7.6.1.2 Settlements converted to Wetlands

HLC\_change and CLC\_change<sub>1990-2000</sub>, CLC\_change<sub>2000-2006</sub> datasets indicate 136, 124 and 171 kha settlements area converted to wetlands in the period 1986-1992, 1992-2000 and 2000-2006, respectively. The CLC codes which were classified into this category are as follows (**Table 7.39**):

**Table 7.39.** Areas classified as ‘Settlements converted to Wetlands’

Period	CLC code	Explanation	Area (kha)
1992-2000			
	131-512	Mineral extraction sites converted to water bodies	76
	133-512	Construction sites converted to water bodies	49
Total			124
2000-2006			
	131-512	Mineral extraction sites converted to water bodies	59
	133-512	Construction sites converted to water bodies	112
Total			171

This land-use change category mainly contains the area of sandpits and gravel pits. The area of these conversions is small. In addition to conversions from extraction and construction area, which are not covered by soil and living biomass. Therefore emissions from this land-use conversion are not estimated and they are reported as ‘NE’. (The potential emissions are assumed to be negligible, probably zero.)

## 7.7 Settlements (CRF sector 5.E)

### 7.7.1 Description of category

Settlements account for 6 per cent of the area of Hungary.

The area of Settlements is derived from extrapolation and interpolation of the HLC-Changes<sub>1985-1990</sub>, CLC-Changes<sub>1990-2000</sub>, HLC-Changes<sub>2000-2006</sub> and, CLC2006. The land-use change data were determined from the HLC-change<sub>1985-1990</sub>, CLC-change<sub>1990-2000</sub>, CLC-change<sub>2000-2006</sub> databases. (For more details see Chapter 7.1 and Annex A3.4.) In this submission area data in the remaining and in the converted to category and emissions from 5.E.2.1 Forest Land converted to Settlements, 5.E.2.2 Cropland converted to Settlements and 5.E.2.3 Grassland converted to Settlements are reported.

### 7.7.2 Settlements remaining Settlements

Not reported. (Parties may decide not to prepare estimate for this category.)

### 7.7.3 Land converted to Settlements

For the estimation of emissions from these conversions a conservative approach was applied, due to a lack of suitable activity data on the living biomass and mineral soils of Settlements. It was assumed, that the areas, which are converted to settlements are paved over during the conversions, therefore there is not any living biomass after the conversions (carbon stocks in living biomass immediately after conversion to settlements and the change in carbon stocks from one year of settlements growth are zero), and 20% of the soil carbon relative to the previous land use will be lost as a result of disturbance, removal, or relocation. Therefore in the estimation of emissions from living biomass  $C_{After}=0$  and  $\Delta C_{Growth}=0$ . In the estimation of emissions from mineral soils  $\Delta C_{LSMineral}=-0.2 \cdot SOC_0 \cdot A/T$ .

#### 7.7.3.1 Forest land converted to Settlements

See Chapter 7.2.3.

#### 7.7.3.2 Cropland converted to Settlements

##### 7.7.3.2.1 Carbon stock change in living biomass

In this category carbon stock change in living biomass of annual croplands and perennial croplands converted to Settlements are reported.

The carbon stock change in living biomass in category 5.E.2.2 Cropland converted to Settlements amounted to -29 Gg C in 2010.

##### 7.7.3.2.1.1 Choice of methodology

Equation 3.6.1 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LSLB} = A_{Conversion} \cdot (-C_{Before})$$

Where:

$\Delta C_{LSLB}$  = Carbon stock change in living biomass due to land-use conversion to Settlements, tones C year<sup>-1</sup>

$A_{Conversion}$  = annual area of land converted to Settlements

$L_{Conversion}$  = Carbon stock change per area for the type of conversion when land is converted to

$C_{Before}$  = carbon stocks in living biomass before the conversion to Settlements, tones C ha<sup>-1</sup>

##### 7.7.3.2.1.2 Choice of activity data

Activity data used for calculation of carbon stock change in living biomass (Table 7.40) are

different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The estimation of the perennial cropland converted to settlements area is based on the HCSO's removal statistics on vineyard and orchard compared with the HLC-Changes<sub>1985-1990</sub> and CORINE Land Cover-change databases. These land cover-change databases indicated that 1, 1.6 and 4.5 per cent of the vineyard and orchard removal was taken place on areas converted to settlements. The annual cropland area was calculated as the difference between the 'total cropland converted to settlements' and the 'perennial cropland converted to settlements' area.

**Table 7.40.** Activity data for carbon stock change in living biomass under category 5.E.2.2

Year	Area [ha]		
	Annual Cropland converted to Settlements	Perennial Cropland converted to Settlements	Total Cropland converted to Settlements
1985	705	133	838
BY	734	105	838
1986	746	93	838
1987	750	88	838
1988	783	55	838
1989	805	33	838
1990	754	85	838
1991	750	88	838
1992	764	75	838
1993	833	104	938
1994	836	102	938
1995	836	101	938
1996	837	101	938
1997	832	105	938
1998	832	106	938
1999	831	107	938
2000	647	290	938
2001	1659	306	1965
2002	1612	353	1965
2003	1628	337	1965
2004	1644	321	1965
2005	1629	336	1965
2006	1606	359	1965
2007	1603	362	1965
2008	1657	308	1965
2009	1646	319	1965
2010	1634	331	1965

### 7.7.3.2.1.3 Choice of emission factors

For  $C_{\text{Before}}$  the IPCC default value, given for annual croplands were taken into account (5 tC ha<sup>-1</sup>).

## 7.7.3.3 Carbon stock change in soils

### 7.7.3.3.1 Mineral soils

Carbon stock change in mineral soils in category 5.E.2.2 Cropland converted to Settlements amounted to -11 Gg C in 2010.

For the details of the estimation of the  $SOC_0$  of Cropland see Chapter 7.3.

Calculated average carbon stocks of mineral soils for Croplands in Table A3-8 and A3-9 in Annex A3.4.

## 7.7.3.4 Grassland converted to Settlements

### 7.7.3.4.1 Carbon stock change in living biomass

The carbon stock change in living biomass in category 5.E.2.3 Grassland converted to Settlements amounted to -1.7 Gg C in 2010.

#### 7.7.3.4.1.1 Choice of methodology

Equation 3.6.1 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{\text{LSLB}} = A_{\text{Conversion}} \cdot (-C_{\text{Before}})$$

Where:

$\Delta C_{\text{LSLB}}$  = Carbon stock change in living biomass due to land-use conversion to Settlements, tones C year<sup>-1</sup>

$A_{\text{Conversion}}$  = annual area of land converted to Settlements

$C_{\text{Before}}$  = carbon stocks in living biomass before the conversion to Settlements, tones C ha<sup>-1</sup>

#### 7.7.3.4.1.2 Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in Table 7.4, because these changes are reported in the year of the conversion, therefore the rolling 20-year period are not taken into account. The estimated activity data are provided in Table 7.41.

**Table 7.41. Activity data of carbon stock change in living biomass in category 5.E.2.3 (ha)**

	1985	BY	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Area of Grassland converted to Settlements	391	391	391	391	391	391	391	391	391	297	297	297	297	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Area of Grassland converted to Settlements	297	297	297	297	538	538	538	538	538	538	538	538	538	538

#### 7.7.3.4.1.3 Choice of emission factors

$C_{\text{Before}}$  was estimated from the IPCC default values ( $3.132 \text{ tC ha}^{-1}$ ). For more details see "Grassland converted to Cropland" in Chapter 7.3.

#### 7.7.3.4.2 Carbon stock change in soils

##### 7.7.3.4.2.1 Mineral soils

Carbon stock change in mineral soils in category 5.E.2.3 Grassland converted to Settlements amounted to  $-4.2 \text{ Gg C}$  in 2010.

For the details of the estimation of the  $\text{SOC}_0$  of Grassland see Chapter 7.4.

Calculated average carbon stocks of mineral soils for Grasslands in Table A3-10 and A3-11 in Annex A3.4.

#### 7.7.3.5 Wetland converted to Settlements

HLC\_change and  $\text{CLC\_change}_{1990-2000}$ ,  $\text{CLC\_change}_{2000-2006}$  datasets indicate 80, 60 and 185 kha wetland areas were converted to settlements in the period 1986-1992, 1992-2000 and 2000-2006, respectively. The CLC codes which were classified into this category are as follows:

**Table 7.42. Areas classified as 'Wetland converted to Settlements'**

Period	CLC code	Explanation	Area (kha)
1992-2000			
	411-142	Inland marshes converted to sport and leisure facilities	27
	511-142	Water courses converted to sport and leisure facilities	19
	412-133	Peat bogs converted to construction sites	8
	511-133	Water courses converted to construction sites	6
Total			60
2000-2006			
	411-122	Inland marshes converted to road and rail network and associated land	64
	411-133	Inland marshes converted to construction sites	65
	411-142	Inland marshes converted to sport and leisure facilities	6
	512-122	Water bodies converted to road and rail network and associated land	1
	512-131	Water bodies converted to mineral extraction sites	24
	512-133	Water bodies converted to construction sites	31
Total			185

The total area of these conversions is small. In addition to the total area of these conversions contains conversions of water courses and water bodies (Table 7.42) which are not covered



by soil and living biomass. Therefore anthropogenic emissions from these land-use conversions are probably negligible, therefore not estimated and they are reported as 'NE'.

#### 7.7.4 Uncertainties and time-series consistency

Uncertainty estimates for the LULUCF sector were calculated using the Tier 1, 'simple propagation of error' method provided by the GPG for LULUCF (IPCC, 2003).

The uncertainties of the area/activity data are based on expert judgment. The uncertainties of the stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003).

**Table 7.43. Uncertainties in 5.E Settlements**

Source Category	CO <sub>2</sub> Emissions	Uncertainty		
		Area (A)	Stock Change Factor(s)	Combined, u(ADi*EFi)
	Gg	±%		
<b>Total Biomass</b>	130	0	66	66
Biomass in 5.E.2.1	18	23	43	49
Biomass in 5.E.2.2	106	30	75	81
Biomass in 5.E.2.3	6	30	75	81
<b>DOM</b>	2	14	14	20
<b>Total Mineral Soils</b>	66	0	32	32
Mineral Soil 5.E.2.1	10	2	96	96
Mineral Soil 5.E.2.2	41	20	39	43
Mineral soil 5.E.2.3	15	20	42	46
<b>Overall</b>	<b>199</b>	0	45	<b>45</b>

#### 7.7.5 Category-specific recalculations

Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were allocated from the 5.B.1 Cropland remaining Cropland into the appropriate LUC categories, thus as well into the 5.E.2.2 Cropland converted to Settlements for the whole time-series. Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting in minor changes in the reallocated emissions (Table 7.26). The inclusion of emissions from vineyard and orchard removal resulted in changes in the reported emissions from 'annual cropland converted to settlements' have also been changed as a result of the refinement of the estimated area. In the submissions up to 2011 the area of 'annual cropland converted to settlements' was estimated as a steady proportion of the total cropland converted to settlements area, but now it is changeable annually. These changes in the emissions are shown in Table 7.50.

In the course of the General Agricultural Census, 2010 the soil cultivation techniques were first surveyed. The new activity data relating to the soil cultivation techniques resulted in changes in the emissions from mineral soils in the category 5.E.2.2 Cropland converted to Settlements for the period 1998-2009.

Areas under different management practices on Grassland (HAC soils in cold climate zone) were corrected for 2005, and 2009. Corrections of these rounding error resulted in minor changes in the estimated carbon stock changes in mineral soils from 5.E.2.3. Grassland converted to Settlements.

Net effect of recalculations is shown in Table 7.44. The overall impact of recalculations for CO<sub>2</sub> emissions was an increase in emissions from 7 GgCO<sub>2</sub> in 1989 to 78 GgCO<sub>2</sub> in 2007. The main driver behind this increase in emissions is the allocation of CO<sub>2</sub> emissions from

vineyard and orchard removal into the 5.E.2.3. Effects of living biomass of annuals and mineral soils are negligible.

**Table 7.44. Recalculation of CO<sub>2</sub> emissions from 5.E Settlements 1985-2010**

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2010 [Gg CO <sub>2</sub> ]	61	60	61	63	65	67	97	65	
Submission 2011 [Gg CO <sub>2</sub> ]	84	88	82	83	77	75	115	84	
Difference [Gg CO <sub>2</sub> ]	23	29	20	19	12	7	18	19	
Percentage change	37%	48%	33%	30%	19%	11%	19%	30%	
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Submission 2010 [Gg CO <sub>2</sub> ]	52	78	70	84	77	86	93	96	145
Submission 2011 [Gg CO <sub>2</sub> ]	68	101	92	106	99	110	116	120	208
Difference [Gg CO <sub>2</sub> ]	16	23	22	22	22	23	23	24	62
Percentage change	31%	29%	32%	27%	29%	27%	25%	24%	43%
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010 [Gg CO <sub>2</sub> ]	136	152	168	206	144	165	130	130	156
Submission 2011 [Gg CO <sub>2</sub> ]	202	228	241	276	216	243	208	199	225
Difference [Gg CO <sub>2</sub> ]	66	76	73	69	73	77	78	69	69
Percentage change	49%	50%	43%	34%	50%	47%	60%	53%	44%

### 7.7.6 Category-specific planned improvements

Research program on the processing of data of the Hungarian Soil Monitoring System to develop country-specific values for the reference carbon stock of mineral soils has finished. Emissions relating to mineral soils are planned to be revised, applying the new research results.

Further refinement of the uncertainty assessment and the development of Monte Carlo approaches are planned for the next inventory cycle.

## 7.8 Other Land (CRF sector 5.F)

### 7.8.1 Description of category

The Other Land category includes the sparsely vegetated areas, which account for 0.03 percent of the total area of the country (Figure 7.1). The area of the Other Land category was estimated from the CORINE datasets. The Other Land areas are unmanaged, therefore emissions from this category are not reported.

### 7.8.2 Land converted to Other Land

#### 7.8.2.1 Grassland converted to Other Land

CLC-changes<sub>1990-2000</sub> indicates that 6 kha grasslands were converted to other land between 1992 and 2000. The CLC code of this conversion is 321-333, which represents the

conversion of natural grassland to sparsely vegetated area. This conversion is not considered to be a human induced activity therefore emission from this activity is not reported. In the CRF table 5.F.2.3 notation key 'NE' is reported for the carbon-stock change in mineral soils for the period 1992-2010.

## 7.9 Non-CO<sub>2</sub> emissions

### 7.9.1 Direct N<sub>2</sub>O 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.

### 7.9.2 N<sub>2</sub>O 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.

### 7.9.3 N<sub>2</sub>O emissions from disturbance associated to land-use conversion to Cropland (CRF sector 5(III))

N<sub>2</sub>O emissions from disturbance associated to land-use conversion to Cropland are calculated for mineral soils in 5.B.2.1 Forest Land converted to Cropland and 5.B.2.2 Grassland converted to Cropland (N<sub>2</sub>O emissions from disturbance associated to land-use conversion from 5.B.2.6. Other Land converted to Cropland was also reported in the previous submission. But it was reallocated into the 5.B.1 Cropland remaining Cropland category and hence N<sub>2</sub>O emissions are not reported.) The N<sub>2</sub>O emissions are calculated from the obtained carbon stock change in mineral soils, with the IPCC default values, using Equation 3.3.14 and 3.3.15 in GPG for LULUCF (IPCC, 2003).

The emission from this category was 0.09 Gg N<sub>2</sub>O in 2010.

### 7.9.4 Biomass burning (CRF sector 5(V))

In accordance with the Government Decree No. 21/2001(II.14), the on-site burning of living biomass is prohibited in Hungary. The burning of slash on Forest Land is only excluded in the regulation. Therefore, the controlled burning of biomass is reported as "not occurring" for Hungary for land-use categories other than Forest Land. (It has to be noted, that the above mentioned Government Decree has been amended at the end of 2010, therefore the Government Decree No. 306/2010. (XII.14.) is in force relating to field burning of agricultural residues, currently.)

In this category burning of slash and wildfires from Forest Land, and wildfires in cropland and grassland are reported. The emissions from the biomass burning were overall 1.10 Gg CH<sub>4</sub> and 0.01 Gg N<sub>2</sub>O in 2010.

The methodology for estimating non-CO<sub>2</sub> emissions from 5.A Forest Land category is provided in Chapter 7.3.1.3 of this NIR. The information provided in this chapter relates to non-CO<sub>2</sub> emissions from wildfires in cropland and grassland.

#### 7.9.4.1 Choice of method

The Tier 1 method, Equation 3.2.20 given by the GPG for LULUCF (IPCC, 2003) was used for the estimation as follows:

$$L_{\text{fire}} = A \cdot B \cdot C \cdot D \cdot 10^{-6}$$

Where:

$L_{\text{fire}}$  = quantity of GHG released due to fire, tonnes of GHG

A = Area burnt, ha

B = mass of available fuel, kg d.m. ha<sup>-1</sup>

C = combustion efficiency

D = emission factor g (kg.d.m.)<sup>-1</sup>

#### 7.9.4.2 Choice of activity data

Data on the areas affected by wildfires (A) derives from the statistics of the National Directorate General for Disaster Management. Data on the areas affected by wildfires has been collected since 1998, but in the system of data collection a methodological change has been introduced in 2007, therefore more details and complete data are available since then. To avoid inconsistency arising from the methodological changes, data for the period 1998-2007 had to be adjusted. For the period 1998-2007 the average of the areas affected by wildfires over the period 2007-2009 were adjusted to the trends before 2007. For the period 1985-1997 the average of the emissions since 1998 are reported, due to lack of data.

According to the GPG for LULUCF (IPCC, 2003) the mass of available fuel (B) was assumed to be 10 t d.m. ha<sup>-1</sup> in Cropland, and 1.641 t d.m. ha<sup>-1</sup> in Grassland. The mass of available fuel for Grassland was estimated as the aboveground biomass on Grassland according to the climate zones distribution from the Table 3.4.2 of the GPG for LULUCF (IPCC, 2003). (See also Chapter 7.3)

The combustion efficiency (C) was 0.5 in accordance with the GPG for LULUCF (IPCC, 2003).

#### 7.9.4.3 Choice of emission factors

The emission factors (D) were taken from the Table 3.A.1.16 of the GPG for LULUCF (IPCC, 2003), the values are shown in Table 7.34.

**Table 7.45. Emission factors for biomass burning**

Gases	Emission Factors [g / (kg d.m.) <sup>-1</sup> ]	
	Cropland	Grassland
CH <sub>4</sub>	5.5	3
N <sub>2</sub> O	0.1	0.11

Source: Table 3.A.1.16 of GPG for LULUCF (IPCC, 2003)

### 7.10 Uncertainty and time-series consistency

Uncertainty estimates for the LULUCF sector were calculated using the Tier 1, 'simple propagation of error' method provided by the GPG for LULUCF (IPCC, 2003). The equation 5.2.1 was applied to estimate the category uncertainties, while the overall uncertainties of different land-use categories and the uncertainties in the total emissions from LULUCF were calculated using the equation 5.2.2 of the GPG for LULUCF (IPCC, 2003).

The uncertainty of the area/activity data is based on expert judgment. The uncertainties of the stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003). The combined uncertainty of the sub-category 5(IV) had to be estimated because the uncertainties of neither the emission factors nor the activity data were available.

Emissions/removals from each land-use category are the sum of emissions/removals from the different carbon pools. Therefore only the overall uncertainties are provided here by land-

use categories. The uncertainties in the activity data and emission factors/stock change factors are significantly different within the land-use categories. These detailed uncertainties are provided in the sub-sectorial chapters.

The application of uncertainty analysis for the LULUCF sector using the IPCC Tier 1 methodology indicates an overall uncertainty level of  $\pm 52\%$  in the 2010 inventory. This value is determined largely by the uncertainty in estimates of CO<sub>2</sub> removals in the 5.A Forest Land category, which is the major source of removals in the Hungarian LULUCF inventory and for which the input data and the methodology are the most reliable.

The 5.C.2 Land converted to Grassland category has the highest overall uncertainty ( $\pm 593\%$ ) in the LULUCF inventory, because of the low level of the net emissions (39 Gg). This value represents the overall uncertainty in the net emissions from the living biomass, dead organic matter, and mineral soils carbon pools. The combined uncertainty for the different carbon pools (80, 20, 52 per cent, respectively) are significantly lower than the overall uncertainty for the sub-sector, because the emission from living biomass and removal from mineral soils are approximately equivalent. Therefore, when combining uncertainties of carbon pools to estimate the overall uncertainty, the denominator becomes three order of magnitude lower than the numerator, resulting in extremely high value for the overall uncertainty of the land-use category. (The emissions are considered with positive and removals are considered with negative signs in accordance with the GPG for LULUCF (IPCC, 2003), when overall uncertainty is calculated for the land-use categories using the Equation 5.2.2.) It has to be emphasized, that the net emission from 5.C.2 is low; therefore there is neither significant influence of this high uncertainty on the overall uncertainty of the LULUCF sector nor the overall uncertainty in national total emission.

The CO<sub>2</sub> removals are dominant estimated to have an uncertainty of  $\pm 52\%$ . The impact of non-CO<sub>2</sub> emissions on LULUCF uncertainty is negligible because they account for only 1.5% of the total net removals.

The overall uncertainties in emissions from the LULUCF sector are shown by gases and by land-use categories in Table 7.46, Table 7.47 and Table 7.49.

**Table 7.46.** Overall uncertainties in CO<sub>2</sub> emissions/removals from 5.LULUCF by land-use categories

Land-Use Categories	Emissions	Uncertainty of Activity Data	Uncertainty of Emission Factor	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub>	%	%	%
5.A.1. Forest Land remaining Forest Land	-1,995	$\pm 6$	$\pm 25$	$\pm 26$
5.A.2. Land converted to Forest Land	-1,124	$\pm 20$	$\pm 48$	$\pm 52$
5.B.1. Cropland remaining Cropland	-1,165	0	$\pm 127$	$\pm 127$
5.B.2. Land converted to Cropland	218	0	$\pm 51$	$\pm 51$
5.C.1. Grassland remaining Grassland	405	0	$\pm 49$	$\pm 49$
5.C.2. Land converted to Grassland	39	0	$\pm 593$	$\pm 593$
5.E.2. Land converted to Settlements	199	0	$\pm 45$	$\pm 45$
<b>Overall uncertainty in CO<sub>2</sub> removal</b>	<b>-3,423</b>	<b>0</b>	<b><math>\pm 52</math></b>	<b><math>\pm 52</math></b>

**Table 7.47.** Overall uncertainties in CH<sub>4</sub> emissions from 5.LULUCF by land-use categories

Land-Use Categories	Emissions	Uncertainty of Activity Data	Uncertainty of Emission Factor	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub> -eq	%	%	%
5.A. Forest Land	22.5	0	±6	±6
5.B Cropland	0.3	±25	±70	±74
5.C Grassland	0.2	±25	±70	±74
<b>Overall uncertainty in CH<sub>4</sub> and N<sub>2</sub>O emissions</b>	<b>23</b>	<b>0</b>	<b>±6</b>	<b>±6</b>

**Table 7.48.** Overall uncertainties in N<sub>2</sub>O emissions from 5. LULUCF by land-use categories

Land-Use Categories	Emissions	Uncertainty of Activity Data	Uncertainty of Emission Factor	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub> -eq	%	%	%
5.A. Forest Land	2.3	0	±1	±1
5.B Cropland	25.4	0	-98 / +273	-98 / +273
5.C Grassland	0.1	±25	±70	±74
<b>Overall uncertainty in N<sub>2</sub>O emissions</b>	<b>28</b>	<b>0</b>	<b>-90 / +250</b>	<b>-90 / +250</b>

**Table 7.49.** Overall uncertainties in net emissions/removals from 5.LULUCF by land-use categories

Land-Use Categories	Emissions	Combined Uncertainty of Emissions
	CO <sub>2</sub> -eq	%
5.A.1. Forest Land remaining Forest Land	-1,970	±26
5.A.2. Land converted to Forest Land	-1,124	±52
5.B.1. Cropland remaining Cropland	-1,165	±135
5.B.2. Land converted to Cropland	218	±54
5.C.1. Grassland remaining Grassland	406	±49
5.C.2. Land converted to Grassland	39	±593
5.E.2. Land converted to Settlements	199	±45
<b>Overall uncertainty in emissions/removals</b>	<b>-3,372</b>	<b>±53</b>

Note: Uncertainties in 5.(IV) is included in 5.B.1

## 7.11 Sector specific QA/QC and verification

Emissions/removals from mineral soils of agricultural lands 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 institutes instead of individuals 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 activity data, methodology used and estimated emissions are checked as follows:

#### Activity data

- Methodological issues of data collections of the land-use/ land-cover data are archived
- The differences between the different land-use datasets are documented
- Consistency of the activity data is checked. In the case of inconsistency (methodological change in the data collection) the dataset are adjusted in consultation with the data provider.
- The data inputs are checked for the transcription errors
- The units of activity data and the transformation are checked in the calculation sheet throughout the emission calculation
- The consistence of the total area of Hungary is checked in the land-use change matrices and the CRF tables
- The activity data are checked with data from other sources, if it is possible.

#### Methodology

- The applied methodologies and emission factors are documented and are compared with the GPG (IPCC, 2003)
- The correctness of the equations and factors in the calculation sheet are checked
- The consistency of the applied methodology is checked through the time series

#### Emissions

- Reported emissions are checked for the transcription errors between the calculation sheet and the CRF tables
- Recalculation differences and reasons for recalculations are checked.

In this inventory cycle there were some significant changes in the allocation of emissions/removals from the LULUCF sector in accordance with the ERT suggestions. The recalculation differences were checked by the member of the HMS's GHG division relating to the whole LULUCF inventory. Before the finalization of the April submission, our check of recalculation differences revealed that the removals relating to the below-ground biomass in forest land was omitted in the course of reallocation. This error has been corrected for the April submission of the CRF tables. Unfortunately, this error had concealed another minor calculation error in the new calculation sheet of the carbon stock change in living biomass under 5.B.1. This error was revealed after submitting the CRF tables in April 2012. Therefore a new set of CRF tables were submitted in May 2012 to the UNFCCC by Hungary, in which this calculation error was corrected.

## 7.12 Sector specific recalculation

Main reasons leading to recalculations in the LULUCF sector for the whole time-series are as follows:

1. In accordance with the ERT recommendation the 5.A.2 Land converted to Forest Land category was revised, and the 20-year transition period has been already applied in accordance with the IPCC methodology. The allocation of these emissions/removals was also revised. All of the emissions/removals were previously reported in the 5.A.2.1 Cropland converted to Forest Land, and now reported separately by former land uses.
2. Emissions from dolomite use were revised as an outcome of the centralized review of the 2011 submission. The emission factor based on the stoichiometric formula of dolomite was used instead of the emission factor provided by the GPG for LULUCF (IPCC, 2003).
3. New data from the HCSO's General Agricultural Census, 2010 resulted in reconsideration of the applied activity data on management practices of mineral



soils for the period 1998-2009.

4. In accordance with the ERT suggestion the allocation was also revised relating to the carbon stock change in living woody biomass on Cropland for the whole time-series. Emissions from removals of woody croplands taking into account in the 'land converted to' categories instead of a 'remaining' category resulted in minor methodological change in the estimation of emissions, because the 'gain' in the carbon stock of the living biomass in the new land-use category (grassland) were formerly omitted and now estimated. As another consequence of this recalculation emissions/removals from conversions of annual croplands were also revised. (Up to 2011 submission a steady ratio of the annual and perennial 'cropland converted to' areas were assumed periodically, but now these areas were determined as a function of the removal of perennial cropland areas.) The effect of the revision of emissions from conversions of annual croplands to other land-uses, and the previously omitted gain in carbon stock of perennial croplands converted to grassland are summarized in Table 7.50.
5. Some minor changes relating to the area data as a result of the annual QC procedure were also made:
  - The former land-use categories of afforested areas were corrected in the period 2007-2009 according to the NFI data.
  - Rounding error in HCSO's removal statistics for orchard and vineyard were corrected for the period 2007-2009 and a transcription error in the calculation sheet for 2006 were also corrected.
  - The estimated area of the different management practices of Grassland (HAC soils in cold climate zone) were corrected for 2005, and 2009.

Details of changes by land-use categories are as follows:

#### 5.A Forest Land

- Revision of the country-specific transition period, introduction of the default 20-year rolling period consistently with the GPG for LULUCF (IPCC, 2003).
- Allocation of emissions/removals from 5.A.2. Land converted to Forest Land was also revised. These emissions were previously reported altogether in the 5.A.2.1 Cropland converted to Forest Land category, but they are now reported separately, by former land-use categories.
- Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were allocated from the 5.B.1 Cropland remaining Cropland into the 5.A.2.1 Cropland converted to Forest Land, as well. Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting in minor changes in the reallocated emissions.

#### 5.B Cropland

- Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were divided according to the appropriate LUCs and allocated from the 5.B.1 Cropland remaining Cropland into the 5.A.2.1 Cropland converted to Forest Land, 5.C.2.2 Grassland converted to Cropland, 5.E.2.2 Cropland converted to Settlements for the whole time-series. Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting in minor changes in the reallocated emissions. As a consequence of this recalculation emissions/removals from conversions of annual croplands were also revised (Table 7.50).

- Emissions from dolomite use were revised as an outcome of the centralized review of 2011 submission. The emission factor based on the stoichiometric formula of dolomite was used instead of the emission factor provided by the GPG for LULUCF (IPCC, 2003).
- In the course of the General Agricultural Census, 2010 the soil cultivation techniques were surveyed for the first time. The new activity data relating to the soil cultivation techniques resulted in changes in the emissions of mineral soils in the 5.B.1 Cropland remaining Cropland, 5.B.2.1 Forest Land converted to Cropland, 5.C.2.1 Grassland converted to Cropland.

#### 5.C Grassland

- Areas under different management practices on Grassland (HAC soils in cold climate zone) must be revised to correct rounding errors for 2005, and 2009. This correction resulted in minor changes in the estimated carbon stock changes in mineral soils in 5.C.1. Grassland remaining Grassland.
- The former land-use categories of afforested areas were corrected for the period 2007-2009 according to the NFI data. This change has effect on the estimated SA-Cropland and SA-Grassland areas and as a consequence the emissions/removals of these categories.
- Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were allocated from the 5.B.1 Cropland remaining Cropland into the 5.C.2.2 Cropland converted to Grassland, as well. Emissions from removals of woody croplands taking into account in the 5.C.2.2 Cropland converted to Grassland category instead of a 'remaining' category resulted in minor methodological change in the estimation of emissions, because the 'gain' in the carbon stock of the living biomass in the new land-use category were formerly omitted and now estimated. As another consequence of this recalculation emissions/removals from conversions of annual croplands to grassland were also revised.
- Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting in minor changes in the reallocated emissions.

#### 5.E Settlements

- Emissions from carbon stock change in living biomass on removed vineyard and orchard areas due to land-use changes were allocated from the 5.B.1 Cropland remaining Cropland into the 5.E.2.2 Cropland converted to Settlements as well, for the whole time-series. Some rounding and transcription error were also corrected in the HCSO's orchard and vineyard removal statistics for the period 2006-2009 resulting in minor changes in the reallocated emissions. As another consequence of this recalculation emissions/removals from conversions of annual croplands to grassland were also revised.
- In the course of the General Agricultural Census, 2010 the soil cultivation techniques were surveyed for the first time. The new activity data relating to the soil cultivation techniques resulted in changes in the emissions of mineral soils in the 5.E.2.2 Cropland converted to Settlements for the period 1998-2009.
- Areas under different management practices on Grassland (HAC soils in cold climate zone) were revised to correct rounding errors for 2005, and 2009. This correction resulted in minor changes in the estimated carbon stock changes in mineral soils from 5.E.2.3. Grassland converted to Settlements.

The impact of recalculations was generally an increase of removals up to 298 Gg CO<sub>2</sub> in

2009, but removals slightly decreased in some other years (in the period 1987-1990 and in 2007). The percentage change was the highest in 1985, because of the low level of removals. The main driver behind these changes is the decrease in carbon losses in annual cropland conversions, and the inclusion of gain in the carbon stock of perennial cropland converted to grassland (Table 7.50) for the early years of the time-series 1985-2009. Changes in the removals in the latter years also reflect the effect of revision of emissions from mineral soils resulted in higher changes in the removals. The effect of recalculation of lime application is negligible. Net effect of recalculations is shown in Table 7.51.

**Table 7.50.** *Impact of recalculations on CO<sub>2</sub> emissions from conversions from annual croplands (C(a)) and perennial croplands (C(p)) to grassland'*

Year	C(a)G						C(p)G			C(a)S			Net change (GgC)	Net change (Gg CO <sub>2</sub> )
	Gain			Losses			Gain			Losses				
	Submission 2011	Submission 2012	Diferrence	Submission 2011	Submission 2012	Difference	Submission 2011*	Submission 2012	Difference	Submission 2011	Submission 2012	Diference		
1985	16.14	13.38	-2.76	-25.77	-21.35	4.41	0.00	3.34	3.34	-4.08	-3.53	0.55	5.54	-20.32
BY	10.76	9.26	-1.50	-17.18	-14.78	2.40	0.00	1.89	1.89	-4.08	-3.67	0.41	3.20	-11.72
1986	16.14	14.40	-1.74	-25.77	-22.98	2.78	0.00	2.32	2.32	-4.08	-3.73	0.35	3.71	-13.62
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.08	-3.75	0.33	0.33	-1.22
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.08	-3.92	0.16	0.16	-0.60
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.08	-4.03	0.05	0.05	-0.19
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.08	-3.77	0.31	0.31	-1.15
1991	48.42	47.94	-0.48	-77.30	-76.54	0.76	0.00	2.21	2.21	-4.08	-3.75	0.33	2.83	-10.36
1992	48.42	48.28	-0.13	-77.30	-77.08	0.21	0.00	1.87	1.87	-4.08	-3.82	0.26	2.21	-8.11
1993	19.22	16.92	-2.30	-30.69	-27.02	3.67	0.00	4.08	4.08	-4.46	-4.17	0.29	5.74	-21.06
1994	19.22	17.03	-2.20	-30.69	-27.18	3.51	0.00	3.98	3.98	-4.46	-4.18	0.28	5.57	-20.43
1995	19.22	17.05	-2.17	-30.69	-27.22	3.47	0.00	3.96	3.96	-4.46	-4.18	0.28	5.54	-20.30
1996	19.22	17.07	-2.15	-30.69	-27.25	3.43	0.00	3.94	3.94	-4.46	-4.18	0.28	5.50	-20.16
1997	19.22	16.89	-2.34	-30.69	-26.96	3.73	0.00	4.12	4.12	-4.46	-4.16	0.30	5.81	-21.32
1998	19.22	16.88	-2.34	-30.69	-26.95	3.74	0.00	4.13	4.13	-4.46	-4.16	0.30	5.82	-21.35
1999	19.22	16.84	-2.38	-30.69	-26.88	3.80	0.00	4.17	4.17	-4.46	-4.16	0.30	5.89	-21.59
2000	19.22	17.94	-1.29	-30.69	-28.63	2.05	0.00	3.07	3.07	-4.46	-3.24	1.22	5.06	-18.55
2001	5.19	2.55	-2.63	-8.28	-4.08	4.21	0.00	3.23	3.23	-9.54	-8.3	1.24	6.05	-22.17
2002	5.19	2.05	-3.13	-8.28	-3.28	5.00	0.00	3.73	3.73	-9.54	-8.06	1.48	7.08	-25.98
2003	5.19	2.22	-2.97	-8.28	-3.55	4.73	0.00	3.56	3.56	-9.54	-8.14	1.40	6.73	-24.69
2004	5.19	2.39	-2.80	-8.28	-3.82	4.46	0.00	3.39	3.39	-9.54	-8.22	1.32	6.38	-23.41
2005	5.19	2.23	-2.96	-8.28	-3.56	4.72	0.00	3.55	3.55	-9.54	-8.14	1.40	6.72	-24.63
2006	5.19	1.99	-3.20	-8.28	-3.18	5.11	0.00	3.80	3.80	-9.54	-8.03	1.51	7.22	-26.46
2007	5.19	1.96	-3.23	-8.28	-3.12	5.16	0.00	3.83	3.83	-9.54	-8.01	1.53	7.29	-26.73
2008	5.19	2.53	-2.66	-8.28	-4.03	4.25	0.00	3.26	3.26	-9.54	-8.28	1.26	6.11	-22.41
2009	5.19	2.41	-2.78	-8.28	-3.85	4.43	0.00	3.37	3.37	-9.54	-8.23	1.31	6.34	-23.25

**Table 7.51.** *The net effect of recalculations on CO<sub>2</sub> removals in LULUCF sector*

	BY	1985	1986	1987	1988	1989	1990	1991	
Submission 2011 [Gg CO <sub>2</sub> ]	-2 199	-86	-3 038	-3 474	-4 461	-3 671	-1 991	-2 293	
Submission 2012 [Gg CO <sub>2</sub> ]	-2 209	-105	-3 050	-3 472	-4 458	-3 668	-1 988	-2 302	
Difference [Gg CO <sub>2</sub> ]	-9	-19	-12	2	3	3	3	-9	
Percentage change	0%	22%	0%	0%	0%	0%	0%	0%	
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Submission 2011 [Gg CO <sub>2</sub> ]	-3 359	-5 319	-5 790	-5 825	-1 913	-2 085	-3 117	-1 484	-428
Submission 2012 [Gg CO <sub>2</sub> ]	-3 365	-5 339	-5 809	-5 845	-1 932	-2 105	-3 140	-1 511	-455
Difference [Gg CO <sub>2</sub> ]	-7	-21	-20	-20	-19	-21	-23	-27	-27
Percentage change	0%	0%	0%	0%	1%	1%	1%	2%	6%
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2011 [Gg CO <sub>2</sub> ]	-1 769	-968	-3 130	-2 187	-4 293	-2 344	-2 754	-3 988	-3 072
Submission 2012 [Gg CO <sub>2</sub> ]	-1 831	-1 066	-3 259	-2 347	-4 485	-2 379	-2 748	-4 258	-3 370
Difference [Gg CO <sub>2</sub> ]	-62	-98	-129	-160	-192	-35	6	-269	-298
Percentage change	4%	10%	4%	7%	4%	1%	0%	7%	10%

### 7.13 Sector specific planned improvements

Further verification of both the activity data, as well as the factors applied seems still necessary relating to 5.A Forest Land category, and is planned in the future.

Refinement of definitions of DOM pools is also planned, in which the exact distinction of litter and accumulated smaller branches on the ground is needed and is planned to be made.

Accumulation models for deadwood in AR areas, based on chronosequences of different forest types, are also planned to be developed.

Non-CO<sub>2</sub> emissions on L-FL area may be calculated separately from FL-FL, to estimate the (otherwise negligible) emissions of these processes. Because of the longer transition period, the short rotation coppices may even have final cuts in 20 years.

A small project started to derive a methodology to sampling possible organic soils (marshes) under forests areas. Until 2014 we may have some data on whether these marshes (approx. 9500 ha) could be regarded as organic soils on p. 3.37 of Annex 3A.5 of Guideline (IPCC, 2006) definitions.

Research program on the processing of data of the Hungarian Soil Monitoring System to develop country-specific values for the reference carbon stock of mineral soils has been finished. Emissions relating to mineral soils are planned to be revised, applying the new research results.

Further refinement of the uncertainty assessment and the development of Monte Carlo approaches are planned for the next inventory cycle.

## 7.14 Sources - references

- Babos, K., Filló, Z., Somkuti, E., (1979): Haszonfák. Műszaki könyvkiadó, Budapest
- Birkás M. (2002): in Környezetkímélő és energiatakarékos talajművelés – Environment conservation and energy saving tillage.
- Birkás M., Kalmár, T., Fenyvesi, L. and Földesi, P. (2007): Realities and beliefs in sustainable soil tillage. Cereal Research Comm. 35. 2. 257-260.
- Central Agricultural Office, Forestry Directorate web page: [www.mgszh.gov.hu](http://www.mgszh.gov.hu)
- CORINE Land Cover (CLC) map displays (1990, 2000)
- Environmental Report of Hungary (HCSO, 2006)
- Forgács, L., Zsembeli, J., and Tuba G. (2005): Examination of a soil protective cultivation method in the Research Institute of Karcag. Realizáciou poznatkov vedy a vyskumu k trvalo udrzatel'nému poľ'nohospodárstvu. Michalovce, Slovakia. 64-68.
- Genetic soil types of Hungary (Agrotopo 2000)
- FÖMI (2004): Final Report CLC2000-Hungary
- FÖMI (2009a): Final Report CLC2006-Hungary
- FÖMI (2009b): Üvegházhatású gázok kibocsátási leltárához kapcsolódó részfeladatok elvégzése. [Sub-project for making GHG-inventory]
- Gyuricza, Cs., Földesi, P., Mikó, P., Ujj, A. (2005): Carbon Dioxide Emission from Arable Lands. Cereal Res. Com., 33. 1. 89-92.
- Kecskés Csaba (1997): Methodological changes in land-use statistics. Statisztikai szemle. Vol 75. No. 12. 1047-1061 (in Hungarian, with English summary).
- Király L. (1978): Új eljárások a hosszú lejáratú erdőgazdasági üzemtervek készítésében. Kandidátusi értekezés, Budapest
- Kovács, I. 1979. Faanyagismerettan. Mezőgazdasági Kiadó, Budapest
- Z. Nagy, K. Pintér, Sz. Czóbel, J. Balogh, L. Horváth, Sz. Fóti, Z. Barcza, T. Weidinger, Zs. Csintalan, N.Q. Dinh, B. Grosz and Z. Tuba, (2007). The carbon budget of semi-arid grassland in a wet and a dry year in Hungary. Agriculture, Ecosystems and Environment 121 (2007) 21–29.
- Short description of the hungarian forest management web page in English: [http://www.mgszh.gov.hu/data/cms/140/140/Forest\\_database\\_2.pdf](http://www.mgszh.gov.hu/data/cms/140/140/Forest_database_2.pdf)
- Statistical Yearbooks for Agriculture (1965-2006)
- Somogyi Z. (2006): How to demonstrate if a pool is not a source? – case study: forest soils is Hungary, Detached National Expert Forest Research Institute, Budapest  
([http://afoludata.jrc.it/events/Kyoto\\_technical\\_workshop/presentations/Z\\_Somogyi.pdf](http://afoludata.jrc.it/events/Kyoto_technical_workshop/presentations/Z_Somogyi.pdf))
- Somogyi, Z., Horváth, B. (2006): Az 1930 óta telepített erdők szénlekötéséről. Erdészeti Lapok CLI. 9. 257-259.

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](http://www.metla.fi/tapahtumat/2006/soil2006).)

Somogyi Z. (2008): A hazai erdők üvegház hatású gáz leltára. Erdészeti kutatások 2007-2008. Vol. 92. 154.  
(<http://www.erti.hu/ek.php?id=1&fn=vol92>)

Somogyi Z., J. Merganic, J. Merganicova, Illés G. (2005): CarniInvent WP 8 Final Report – D8.5 Guidelines and improved standards for monitoring and verification of carbon removals in afforestation/reforestation joint implementation projects. Result of the monitoring case study in the test site in Hungary  
([www.joanneum.at/carboinvent/D\\_8\\_5.pdf](http://www.joanneum.at/carboinvent/D_8_5.pdf))

Sopp L. (1974): Fatömegszámítási táblázatok. Mezőgazdasági Kiadó, Budapest

Temperature zone maps (1971-2000)

Tóth, E. and Koós, S.: 2006. Carbon dioxide emission measurements in a tillage experiment on chernozem soil. Cereal Research Communications. Vol. 34. No. 1. 331-334.

[www.akii.hu](http://www.akii.hu)

[www.ksh.hu](http://www.ksh.hu)

Zsembeli, J. and Kovács Gy. (2007): Dynamics of CO<sub>2</sub>-emission of the Soil in Conventional and Reduced Tillage Systems. Cereal Research Communications. Vol. 35. No. 2. 1337-1340.

Zsembeli, J., Tuba G. and Kovács Gy. (2006): Development and extension of CO<sub>2</sub>-emission measurements for different soil surfaces. Cereal Research Communications. Vol. 34. No. 1. 359-362.

Zsembeli, J., Tuba, G. and Forgács, L. (2005): CO<sub>2</sub>-emission of soil in an energy saving soil cultivation system. Realizáciou poznatkov vedy a vyskumu k trvalo udržateľnému poľnohospodárstvu. Michalovce, Slovakia



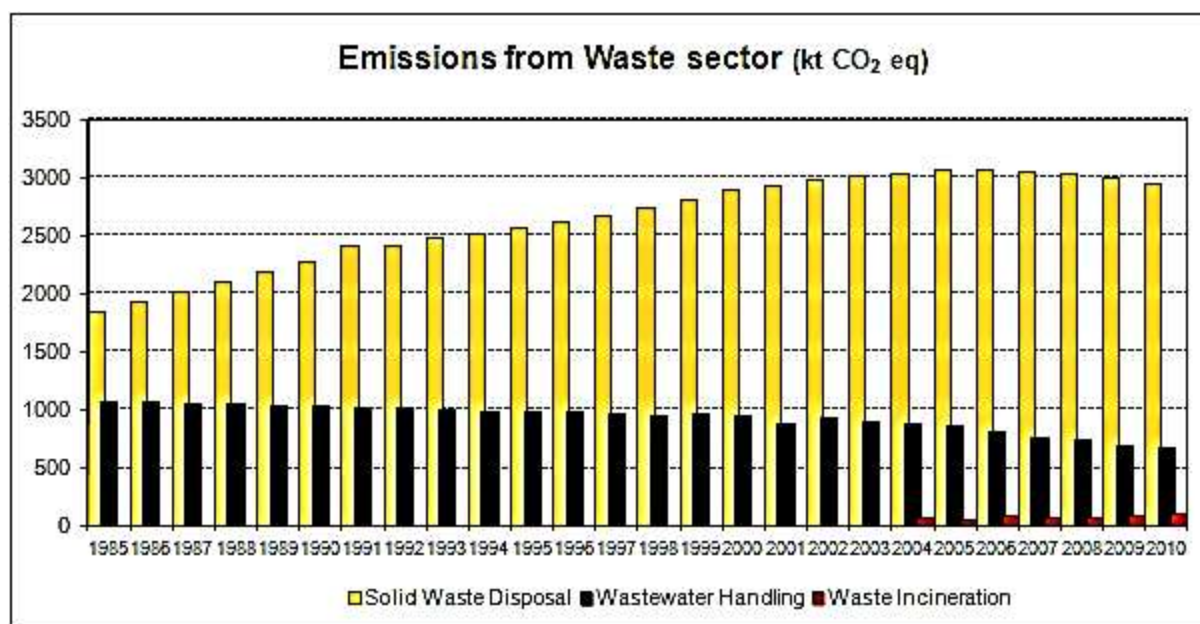
## 8 Waste (CRF sector 6.)

### 8.1 Overview of sector

This section discusses the emissions from municipal solid waste disposal ( $\text{CH}_4$ ), municipal and industrial wastewater treatment ( $\text{CH}_4$  and  $\text{N}_2\text{O}$ ) and waste incineration ( $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{N}_2\text{O}$ ). One peculiarity of the sector is that a part of the carbon-dioxide emissions is generated from biological (biogenic) sources and this  $\text{CO}_2$  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 (MSW) 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. The total amount of MSW was 4,129 Gg in 2010. Out of this 4,129 Gg MSW, 885 Gg (17%) was recovered by recycling and composting, 406 Gg (10%) was incinerated for energy purposes, 2,838 Gg (69%) went to landfills. (In previous years 30-230 Gg waste was treated in other ways which meant mostly mechanical biological treatment (MBT) that produced refuse-derived fuel that could be used in power plants and cement factories.)

The waste sector with 3,687.11 Gg  $\text{CO}_2$  equivalent represented 5.4% of total national GHG emissions in 2010. In the base year, total GHG emissions from the waste sector amounted to 3,076.30 Gg  $\text{CO}_2$  equivalent which accounted for 2.7% of total national GHG emissions. In contrast with other sectors, emissions from the waste sector showed significant increase from the base year (+19.9%). However, the growth of emissions seemed to be stopping in recent years, moreover, a reduction of 6.8% could be observed between 2005 and 2010. In all the years, the largest category was solid waste disposal on land, representing 79.9% in 2010, followed by wastewater handling (17.7%) and waste incineration (2.4%). 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<sub>4</sub>

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<sub>2</sub> generated in landfills is of biogenic origin and is thus excluded from the inventory. Under the conditions prevailing in landfills, CO<sub>2</sub> 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<sub>2</sub> emission has to be included in this category.

### 8.2.2 Methodological issues

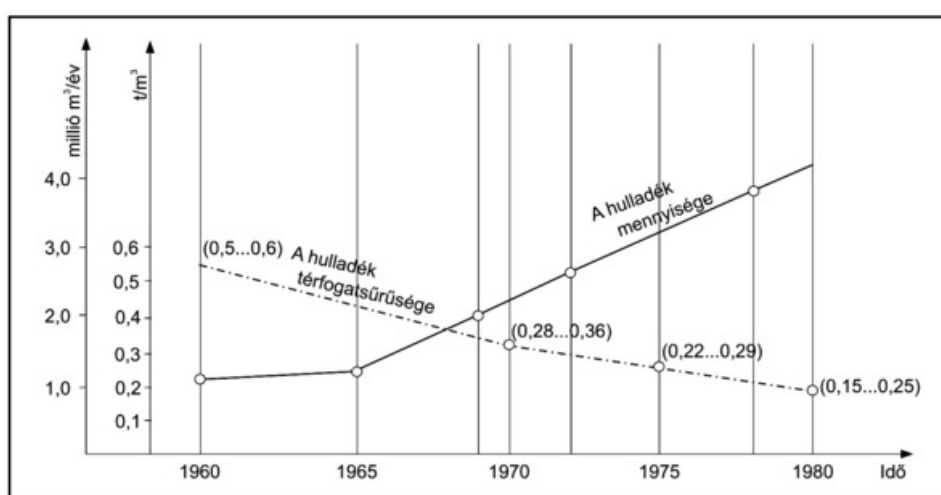
Emissions were calculated using a first order decay methodology, as response to the recommendations of the ERT in 2007. For the calculations, the IPCC Waste Model from the 2006 IPCC Guidelines was used. The FOD method produces a time-dependent emission profile which may better reflect the true pattern 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<sub>2</sub> 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 ( $\text{m}^3$ ), therefore these data had to be converted to mass unit using the gravimetric density ( $\text{t}/\text{m}^3$ ) as an important physical characteristic of the waste. Between 1975 and 2000, the value of this parameter decreased from  $0.3 \text{ t}/\text{m}^3$  to  $0.2 \text{ t}/\text{m}^3$  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 ( $\text{t}/\text{m}^3$ )	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 and methane generation rate constant of different MSW components

	DOC			Methane generation
	IPCC GPG	IPCC 2006 GL.	Used values	rate constant (k)
<b>MCF</b>	1.0	1.0	<b>1.0</b>	
<b>Paper</b>	0.4	0.4	<b>0.4</b>	<b>0.04</b>
<b>Textiles</b>	0.4	0.24	<b>0.24</b>	<b>0.04</b>
<b>Food</b>	0.15	0.15	<b>0.16</b>	<b>0.06</b>
<b>Sewage sludge</b>	-	0.05	<b>0.05</b>	<b>0.06</b>
<b>Hygienic waste</b>	-	0.24	<b>0.24</b>	<b>0.05</b>
<b>DOC<sub>F</sub></b>	0.77	0.5	<b>0.5</b>	

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<sub>4</sub> 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]
<b>1950</b>	1800	22%	5%	30%			<b>0</b>	
<b>1975</b>	1872	19%	6%	30%			<b>58.9</b>	
<b>Base year</b>	<b>4018</b>	<b>19%</b>	<b>6%</b>	<b>28%</b>			<b>91.3</b>	<b>178.9</b>
<b>1990</b>	3963	20%	7%	32%			<b>107.8</b>	193.4
<b>1991</b>	3340	18%	3%	38%			<b>112.0</b>	156.2
<b>1992</b>	3506	19%	4%	39%			<b>114.5</b>	171.3
<b>1993</b>	3400	17%	7%	35%			<b>117.6</b>	157.9
<b>1994</b>	3571	18%	5%	33%			<b>119.8</b>	165.4
<b>1995</b>	3576	17%	4%	35%			<b>122.3</b>	160.3

	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane FOD [Gg]	Emitted methane Tier1 [Gg]
1996	3788	19%	3%	32%			124.5	171.7
1997	4023	19%	6%	28%	4%		127.0	190.1
1998	4067	18%	6%	31%	3%		130.2	194.7
1999	4146	20%	5%	31%	3%		133.6	203.1
2000	3847	14%	4%	41%	1%		137.2	167.2
2001	3821	16%	3%	41%	2%		139.3	175.8
2002	3907	16%	3%	31%	2%		141.7	163.1
2003	3966	16%	3%	30%	3%		143.1	160.1
2004	3978	15%	3%	31%	2%		144.3	166.7
2005	4072	15%	3%	29%	2%	0.0	145.4	165.1
2006	3902	16%	4%	24%	3%	0.9	145.5	152.0
2007	3477	11%	4%	25%	3%	1.7	145.2	111.4
2008	3494	13%	4%	24%	3%	1.7	143.9	121.5
2009	3439	12%	4%	24%	4%	2.4	142.4	120.4
2010	2875	14%	5%	23%	5%	3.5	140.3	104.9
<b>Trend</b>	<b>-28%</b>	<b>-29%</b>	<b>-18%</b>	<b>-17%</b>			<b>54%</b>	<b>-41%</b>

### 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 <sub>4</sub> correction factor (=1)	-10 %, +0 %
CH <sub>4</sub> content of landfill gases (0.5)	±5%
CH <sub>4</sub> 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

None.



### 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<sub>4</sub> emissions. We expect more complete recovery data in the future, and we will search for waste composition data representative for other parts of the country.

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

Emitted gas: CH<sub>4</sub>, N<sub>2</sub>O

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<sub>2</sub>O 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<sub>5</sub> = 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<sup>3</sup>/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<sub>4</sub> producing capacities of 0.25 kg CH<sub>4</sub>/kg COD and 0.6 kg CH<sub>4</sub>/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 to 2010.

Usually, collected wastewater undergoes aerobic treatment in the plants. Still, an MCF value between 0.1 and 0.15 was taken (0.15 is 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. However, these emission estimates contain also the emissions from sludge treatment which would justify our choice for a higher value of MCF. 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. However, we started to collect information on the generated sludge and its handling methods, at least for the last six years. These data are based on facility reports and are summarized in Table 8.4.



**Table 8.4.** *Newly collected data on sludge*

	2005	2006	2007	2008	2009	2010
<b>Amount of sludge</b> (dry matter, t/year)	216,485	244,439	211,952	258,705	250,994	288,729
<b>Reported N content</b> (t/year)	2,561	3,187	3,094	3,668	3,256	4,778
<b>Anaerobic digesting</b> (t/year)	18,085	24,093	25,625	39,484	47,716	109,209
<b>Share of anaerobic digesting</b> (%)	8%	10%	12%	15%	19%	38%

It has to be emphasized that 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 8.5.** *Summary of emission estimates from wastewater treatment*

	Connected to public sewerage	Untreated or primary treatment	Secondary and tertiary treatment	Recovery Gg CH <sub>4</sub>	Emissions domestic wastewater [Gg CH <sub>4</sub> ]	Emissions industrial wastewater [Gg CH <sub>4</sub> ]
<b>Base year</b>	39%	55%	45%		38.85	6.45
1990	41%	50%	50%		37.42	5.80
1991	42%	50%	50%		37.26	5.50
1992	42%	50%	50%		37.11	5.20
1993	42%	50%	50%		36.92	4.90
1994	43%	50%	50%		36.71	4.62
1995	43%	50%	50%		36.51	5.73
1996	43%	50%	50%		36.30	5.67
1997	45%	44%	56%		36.05	5.61
1998	47%	42%	58%		35.40	5.75
1999	49%	33%	67%		35.63	5.68
2000	50%	33%	67%		34.76	5.55
2001	52%	36%	64%	1.71	31.84	5.47
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
2009	72%	28%	72%	8.75	19.75	2.91
2010	73%	2%	98%	8.31	19.32	2.45
<b>Trend</b>					<b>-50%</b>	<b>-62%</b>

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<sub>2</sub>O-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 8.6. Protein consumption and the resulting N<sub>2</sub>O emissions**

	Protein consumption [g/capita/day]	Nitrous oxide emission [Gg N <sub>2</sub> O]
<b>Base year</b>	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	101.3	0.64
2008	100.6	0.64
2009	99.5	0.63
2010	99.5	0.63

### 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 <sub>4</sub> production capacity $B_0$ :	-30 % to + 30 %

Uncertainty of N<sub>2</sub>O 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 have been re-estimated now for the entire time series, i.e. this time for the period 1985-2001, therefore the consistency of the time series improved significantly.

### **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**

Most importantly, CH<sub>4</sub> emissions from industrial wastewater have been reestimated for the period 1985-2001 to ensure consistency in the time series. For more details see chapter 10.6. Also a minor change in N<sub>2</sub>O emissions occurred due to revision of protein consumption data for the year 2009.

### **8.3.6 Planned improvements**

We'll check the possibility to report emissions from sludge treatment separately based on the newly collected data.

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

Emitted gases: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O

Key source: none

### **8.4.1 Source category description**

This subsector covers only emissions from thermal waste treatment without energy recovery (D10). In 2010, 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<sub>2</sub> 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<sub>2</sub> is emitted out of which only the fossil part contributes to the total emissions. (Biogenic CO<sub>2</sub> 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<sub>2</sub>O generation is also minimal.

### **8.4.2 Methodological issues**

For estimating CO<sub>2</sub> 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 an interesting fact that 82 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 8.7.** *Incinerated waste and CO<sub>2</sub> emissions from fossil origin*

	BY	1990	1995	2000	2004	2005	2006	2007	2008	2009	2010
<b>Incinerated waste (Gg)</b>	NO	NO	NO	NO	54.07	46.56	68.90	65.06	63.66	69.87	84.53
<b>Fossil fraction (%)</b>	--	--	--	--	98%	96%	99%	92%	95%	89%	95%
<b>Fossil CO<sub>2</sub>, Gg</b>	--	--	--	--	52.19	46.98	69.93	64.05	64.12	68.17	84.31

The N<sub>2</sub>O emissions were calculated using the default value for industrial waste from Table 5.6 in the 2006 Guidelines that is 100 g N<sub>2</sub>O / t industrial waste. CH<sub>4</sub> 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**

No recalculation has been taking place.

## 9 OTHER (CRF sector 7.)

This sector is 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.

### 10.2 Energy sector

#### 10.2.1 1.AA.1.C Manufacture of Solid Fuels – Solid Fuels

It was revealed during our QC procedures that emissions from coke oven gas are partly missing from the inventory, at least for the period 1985-2005. As the Hungarian Energy Statistics Yearbooks did not contain coke oven gas final consumption data for all the years, the activity data were taken mostly from the IEA Coal Questionnaire. Default emission factors (13 t C/TJ, 1 kg CH<sub>4</sub>/TJ, 0.1 kg N<sub>2</sub>O/TJ) were used for the calculations. The results are summarized in *Table 10.1* below.

**Table 10.1.** Change in CO<sub>2</sub> emissions due to added coke oven gas consumption recalculations

	ORIGINAL		NEW		diff.
	TJ	Gg CO <sub>2</sub>	TJ	Gg CO <sub>2</sub>	Gg CO <sub>2</sub>
1985	IE	IE	1,286	61.0	61.0
1985-87	IE	IE	1,599	75.8	75.8
1986	IE	IE	1,148	54.5	54.5
1987	IE	IE	2,362	112.0	112.0
1988	IE	IE	2,867	136.0	136.0
1989	IE	IE	2,806	133.1	133.1
1990	IE	IE	2,489	118.1	118.1
1991	IE	IE	2,638	125.1	125.1
1992	IE	IE	2,869	136.1	136.1
1993	IE	IE	3,106	147.3	147.3
1994	IE	IE	3,497	165.9	165.9
1995	IE	IE	3,470	164.6	164.6
1996	IE	IE	3,451	163.7	163.7
1997	IE	IE	3,678	174.5	174.5
1998	IE	IE	3,332	158.0	158.0
1999	IE	IE	3,068	145.5	145.5
2000	IE	IE	3,408	161.6	161.6
2001	IE	IE	2,461	116.7	116.7
2002	IE	IE	1,752	83.1	83.1
2003	IE	IE	1,985	94.2	94.2
2004	IE	IE	1,611	76.4	76.4

	ORIGINAL		NEW		diff.
	TJ	Gg CO2	TJ	Gg CO2	Gg CO2
<b>2005</b>	IE	IE	1,762	90.4	90.4
<b>2006</b>	3,458	155.0	3,458	155.0	0.0
<b>2007</b>	3,751	165.9	3,751	165.9	0.0
<b>2008</b>	3,641	160.4	3,641	160.4	0.0
<b>2009</b>	2,928	137.1	2,928	137.1	0.0

### 10.2.2 Separation of Iron and Steel and Non-Ferrous Metals categories

Following the recommendation of the ERT, Hungary started to report iron and steel and non-ferrous metals separately, at least as regards emissions from natural gas and heavy fuel oil. Although the Hungarian Energy Statistics Yearbooks contained usually aggregated data for these categories as 'metallurgy', current national reports to the IEA made it possible to remove fuel use for non-ferrous metal production from the iron and steel category where all these fuel uses and emissions were allocated in our previous submissions. As the IEA time series start in 1990, data from the energy statistical yearbooks from 1985 to 1989 had to be used as well. Luckily, the editions until 1991 contained separate information on 'iron and steel' and 'metallurgy' thus the difference of these two was regarded as 'non-ferrous metals' in our calculations.

#### Gaseous Fuels:

Natural gas use formerly reported in 1.AA.2.A. Iron and Steel was distributed not only into two but *three* categories: 1.AA.2.A, 1.AA.2.B, and 2.C.1.2! The IEA natural gas questionnaire made this distinction possible; all natural gas use reported as 'Blast Furnaces (Transformation)' was allocated in the latter category. As *Table 10.2* demonstrates, the reallocation of fuel use did not lead to any changes in aggregated emissions from the three 'new' categories.

**Table 10.2.** Fuel use and emissions from natural gas use before and after reallocation in iron and steel and non-ferrous metals categories

	ORIGINAL				NEW				aggregated difference	
	Iron and Steel		Iron and Steel		Non-Ferrous Metals					
	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2
1985	34,584	1,930.44	30,776	1,717.88	3,808	212.56			0.0	0.0
1985-87	35,482	1,980.58	31,557	1,761.49	3,925	219.09			0.0	0.0
1986	35,300	1,970.43	31,275	1,745.75	4,025	224.67			0.0	0.0
1987	36,562	2,040.87	32,620	1,820.83	3,942	220.04			0.0	0.0
1988	30,548	1,705.17	26,509	1,479.72	4,039	225.45			0.0	0.0
1989	29,978	1,673.36	26,013	1,452.03	3,965	221.32			0.0	0.0
1990	25,932	1,447.51	24,377	1,360.70	1,555	86.81			0.0	0.0
1991	16,291	909.36	12,948	722.77	3,343	186.58			0.0	0.0
1992	13,765	768.36	10,735	599.21	3,030	169.15			0.0	0.0
1993	15,288	853.37	12,315	687.43	2,973	165.93			0.0	0.0
1994	12,293	686.19	10,097	563.61	2,196	122.58			0.0	0.0
1995	14,090	786.50	11,891	663.77	2,199	122.73			0.0	0.0



	ORIGINAL				NEW				aggregated difference	
	Iron and Steel		Iron and Steel		Non-Ferrous Metals		Pig Iron		aggregated difference	
	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2
1996	13,220	737.93	10,710	597.82	2,510	140.11			0.0	0.0
1997	11,225	626.57	8,101	452.20	3,124	174.37			0.0	0.0
1998	9,446	527.27	5,296	295.63	4,150	231.65			0.0	0.0
1999	8,600	480.05	4,657	259.96	3,943	220.09			0.0	0.0
2000	8,527	475.97	4,253	237.39	4,274	238.58			0.0	0.0
2001	10,307	575.34	5,436	303.45	4,871	271.89			0.0	0.0
2002	9,336	521.13	4,431	247.34	4,905	273.79			0.0	0.0
2003	7,710	430.37	3,115	173.86	4,595	256.51			0.0	0.0
2004	10,162	567.24	2,956	164.99	4,716	263.24	2,490	139.01	0.0	0.0
2005	11,017	614.96	4,812	268.63	4,172	232.90	2,032	113.44	0.0	0.0
2006	9,783	546.08	3,926	219.14	4,249	237.17	1,608	89.77	0.0	0.0
2007	8,886	496.01	3,468	193.58	3,910	218.23	1,508	84.20	0.0	0.0
2008	8,533	476.29	3,321	185.36	3,926	219.14	1,286	71.79	0.0	0.0
2009	5,199	290.20	2,081	116.17	2,723	152.02	394	22.00	0.0	0.0

#### Liquid Fuels:

Within liquid fuels, heavy fuel oil was the dominant fuel used in these categories representing a share around 90% in the 80's and early 90's. (Nowadays, liquid fuel use is almost negligible.) Thus, the work was concentrated on emissions from heavy fuel use. Based on the data of the IEA Oil questionnaire, heavy fuel oil use in the non-ferrous metals row was subtracted from the original 'iron and steel' category for the years 1985-2001. Emissions were calculated with default emission factors (21.1 t C/TJ, 2 kg CH<sub>4</sub>/TJ, 0.6 kg N<sub>2</sub>O/TJ). As it is all about reallocation, the aggregated fuel use and emissions remained the same with one exception. An outlier was identified for 2004. Analyzing the fuel use statistics, this value turned out to be erroneous and was corrected accordingly. The work will be continued considering some less important fuels (LPG, gasoil).

**Table 10.3.** Fuel use and emissions from liquid fuel use before and after reallocation in iron and steel and non-ferrous metals categories

	ORIGINAL				NEW		Aggregated difference	
	Iron and Steel		Iron and Steel		Non-Ferrous Metals		Aggregated difference	
	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2
1985	9,331	710.42	7,352	558.83	1,979	151.59	0.0	0.0
1985-87	9,472	722.92	7,421	565.89	2,050	157.03	0.0	0.0
1986	9,703	741.64	7,630	582.85	2,073	158.79	0.0	0.0
1987	9,381	716.70	7,283	555.99	2,098	160.71	0.0	0.0
1988	9,033	690.37	6,887	525.99	2,146	164.38	0.0	0.0
1989	10,190	779.05	7,990	610.53	2,200	168.52	0.0	0.0
1990	10,501	803.08	8,652	661.44	1,849	141.64	0.0	0.0
1991	7,082	541.67	5,112	390.80	1,970	150.87	0.0	0.0
1992	6,405	489.55	4,958	378.70	1,447	110.85	0.0	0.0
1993	5,774	441.15	4,689	358.02	1,085	83.13	0.0	0.0
1994	4,507	344.12	3,864	294.86	643	49.26	0.0	0.0
1995	3,801	289.28	3,158	240.02	643	49.26	0.0	0.0

	ORIGINAL		NEW				Aggregated difference	
	Iron and Steel		Iron and Steel		Non-Ferrous Metals			
	TJ	CO2	TJ	CO2	TJ	CO2	TJ	CO2
1996	5,679	433.00	4,553	346.78	1,126	86.21	0.0	0.0
1997	2,406	182.30	2,125	160.75	281	21.55	0.0	0.0
1998	101	7.38	29	1.87	72	5.51	0.0	0.0
1999	61	4.40	22	1.42	39	2.99	0.0	0.0
2000	42	3.11	9	0.58	33	2.53	0.0	0.0
2001	57	4.00	26	1.62	31	2.37	0.0	0.0
2002	18	1.16	18	1.16	0	0.00	0.0	0.0
2003	124	9.05	124	9.05	0	0.00	0.0	0.0
2004	777	74.17	96	6.82	0	0.00	-681.0	-67.3
2005	68	4.81	68	4.81	0	0.00	0.0	0.0
2006	109	7.80	109	7.80	0	0.00	0.0	0.0
2007	135	9.59	135	9.59	0	0.00	0.0	0.0
2008	109	7.72	109	7.72	0	0.00	0.0	0.0
2009	84	5.96	84	5.96	0	0.00	0.0	0.0

### 10.2.3 *Reallocation of emissions from the use of coke as a reducing agent in blast furnaces to the industrial processes sector*

The ERT recommended to report emissions from the use of coke as a reducing agent in blast furnaces in the industrial processes sector. Using previously only the Hungarian Energy Statistical Yearbook where all fuel use in the metal industry was published together as 'metallurgical' fuel use, this allocation was not possible. However, in the IEA Coal questionnaire large part of the coke oven consumption is reported in 'Blast Furnaces (Transformation)' and a smaller part as energy use in the iron and steel industry. Thus, the coke use for transformation was subtracted from source category 1.AA.2.A and moved to 2.C.1 with the corresponding emissions. As the IEA time series start only in 1990, an average share of coke use for transformation (87%) was used for the years 1985-89.

While analyzing more deeply the fuel consumption data, it turned out that emissions from coke oven gas were missing from our previous calculations before 2005. These were added now using default emission factors (13 t C/TJ, 10 kg CH<sub>4</sub>/TJ, 0.1 kg N<sub>2</sub>O/TJ).

**Table 10.4.** *Fuel consumption and emissions from solid fuel use before and after reallocation coke as a reducing agent to the IP sector and addition of coke oven gas*

	ORIGINAL		Moved to 2.C.1	Added coke oven gas		NEW		diff. CO2
	TJ	CO2		TJ	CO2	TJ	CO2	
1985	53,560	5,137.3	39,678	956	45.3	14,837	1,444.5	-3,692.8
1985-87	51,901	4,908.9	37,966	1,212	57.5	15,147	1,411.6	-3,497.3
1986	53,617	5,058.2	38,918	1,255	59.5	15,953	1,468.7	-3,589.5
1987	48,526	4,531.2	35,301	1,425	67.6	14,650	1,321.5	-3,209.7
1988	46,719	4,428.2	34,752	1,706	80.9	13,672	1,285.0	-3,143.2
1989	39,638	3,716.0	30,353	1,761	83.5	11,047	1,012.7	-2,703.3
1990	31,606	2,946.4	28,220	2,571	122.0	5,957	457.2	-2,489.3
1991	25,195	2,409.5	19,998	2,681	127.2	7,878	664.4	-1,745.1
1992	23,578	2,285.8	17,801	2,527	119.9	8,305	716.5	-1,569.3
1993	24,789	2,393.9	21,137	2,355	111.7	6,008	490.0	-1,903.9

	ORIGINAL		Moved to 2.C.1	Added coke oven gas		NEW		diff. CO2
	TJ	CO2		TJ	CO2	TJ	CO2	
1994	28,294	2,744.8	24,207	3,245	153.9	7,332	581.4	-2,163.4
1995	26,487	2,565.4	23,636	3,581	169.8	6,432	468.6	-2,096.8
1996	25,975	2,510.6	22,142	3,050	144.7	6,883	548.3	-1,962.2
1997	19,234	1,818.2	16,337	3,048	144.6	5,946	449.5	-1,368.7
1998	20,455	1,933.4	17,654	2,929	138.9	5,730	435.5	-1,497.9
1999	21,862	2,083.4	17,504	2,509	119.0	6,867	580.7	-1,502.7
2000	21,605	2,048.0	19,022	2,751	130.5	5,335	404.0	-1,644.0
2001	20,301	1,899.0	16,849	1,118	53.0	4,570	418.0	-1,481.0
2002	21,463	2,009.5	18,068	484	23.0	3,879	382.6	-1,626.9
2003	21,377	2,008.7	16,211	1,271	60.3	6,436	607.6	-1,401.1
2004	21,785	2,057.3	16,736	1,625	77.0	6,674	612.2	-1,445.1
2005	21,029	1,975.5	17,403	1,582	75.0	5,209	459.3	-1,516.2
2006	23,798	2,076.4	17,723			6,074	467.3	-1,609.1
2007	25,496	2,210.9	18,271			7,225	564.2	-1,646.7
2008	24,452	2,096.1	17,641			6,811	516.7	-1,579.3
2009	20,938	1,888.0	17,571			3,367	210.0	-1,678.0

#### 10.2.4 Further smaller changes in the energy sector

**Blast furnace gas** consumption and the corresponding emissions were removed from 'public electricity and heat production' category for the year 2005. We think that this should not be reported as an emission source since the carbon content of the blast furnace gas is from the coke or natural gas used in the blast furnace reported entirely in sector 2.C.1.4 and 2.C.1.2 respectively. The resulting change is summarized in Table 10.5

**Table 10.5** Effects of removal of blast furnace gas from public electricity and heat production in 2005

2005	TJ	Gg CO2
ORIGINAL	88462	9209
NEW	84399	8943
CHANGES	-4063	-266

Some inconsistencies were found between the Energy Statistical Yearbooks and the IEA data series regarding **biomass use**.

**Table 10.6** Effects of removal of blast furnace gas from public electricity and heat production in 2005

	ORIGINAL			NEW		
	2007	2008	2009	2007	2008	2009
TJ	10957	11742	14800	22430	19470	24338
Gg CH4	3.29	3.52	4.44	6.73	5.84	7.30
Gg N2O	0.04	0.05	0.06	0.09	0.08	0.10
Diff. Gg CO2 eq				86.50	58.27	71.92

The Energy Statistical Yearbooks usually publish data only on firewood consumption, whereas in the IEA renewable database contain more comprehensive data on biomass use.

It was noticed further that there was a significant drop of biomass use between 2006 and 2007 in the previous submission. Therefore we started to remedy this situation by amending biomass use in the most important *residential category* for the years 2007-2009. Activity data were taken from the IEA Renewable questionnaire ('Solid Biomass // Wood/Wood Wastes/Other Solid Wastes'), and default emission factors were used. Our results are summarized in *Table 10.6*.

Time series of **CH<sub>4</sub> emission from natural gas in Transport sector** was amended as well. For the sake of consistency, the default emission factor (92 kg CH<sub>4</sub>/TJ) is used now for the entire time series. This recalculation, however, had an almost negligible effect on emissions with a maximum increase of 0.21 Gg expressed in CO<sub>2</sub> eq.

### 10.2.5 1.B.2. Fugitive Emissions from Oil and Natural Gas Operations

Since 2010 submission CO<sub>2</sub> and N<sub>2</sub>O emissions from flaring have been reported based on default EF-s from Table 2-16 of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000). During the review process of year 2011 Hungary was encouraged to include other fugitive CO<sub>2</sub> sources from category Natural Gas and Oil. In October 2011 recalculation was made to include CO<sub>2</sub> emissions originating from category Natural Gas Production/Processing based on default EF from Table 2 of Background Papers for IPCC Expert Meeting on Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Background Paper). This recalculation was again recalculated in January 2012 based on the EFs of GPG2000 for fugitive emissions and raw CO<sub>2</sub> venting. (The use of the factors of the GPG2000 for fugitive and flaring categories too are a more accurate, since the use of the Background paper default EF-s in parallel with EF-s of GPG2000 for flaring leads to a significant overestimation of CO<sub>2</sub> emissions.)

In addition, fugitive CO<sub>2</sub> emissions are reported in category Oil production (Conventional Oil), Oil Transport and Condensates Transport as well. The same activity data is needed as for CH<sub>4</sub> emissions.

It is worth to mention that IEF for fugitive CO<sub>2</sub> emissions of Natural Gas Production/Processing seems very unstable. The reason is that activity data for Natural Gas Production/Processing is Natural Gas Produced in PJ including all types (e.g.: Sweet Gas, Sour Gas). However CO<sub>2</sub> emissions are closely related to amount of sour gas production, since the main source of CO<sub>2</sub> is category Raw CO<sub>2</sub> venting having sour gas production as unit of measure of the Emission Factor.

Reported AD was changed from gas consumed (PJ) to Natural Gas transmission pipelines (km) to have more stable IEF too, as the latter is the unit of measure of the EF used.

In addition a mistype error for year 2007 in category 1.B.2.Biv Natural gas distribution CH<sub>4</sub> emission was corrected and activity data for category 1.B.2.D Other CH<sub>4</sub> emission from thermal water was added.

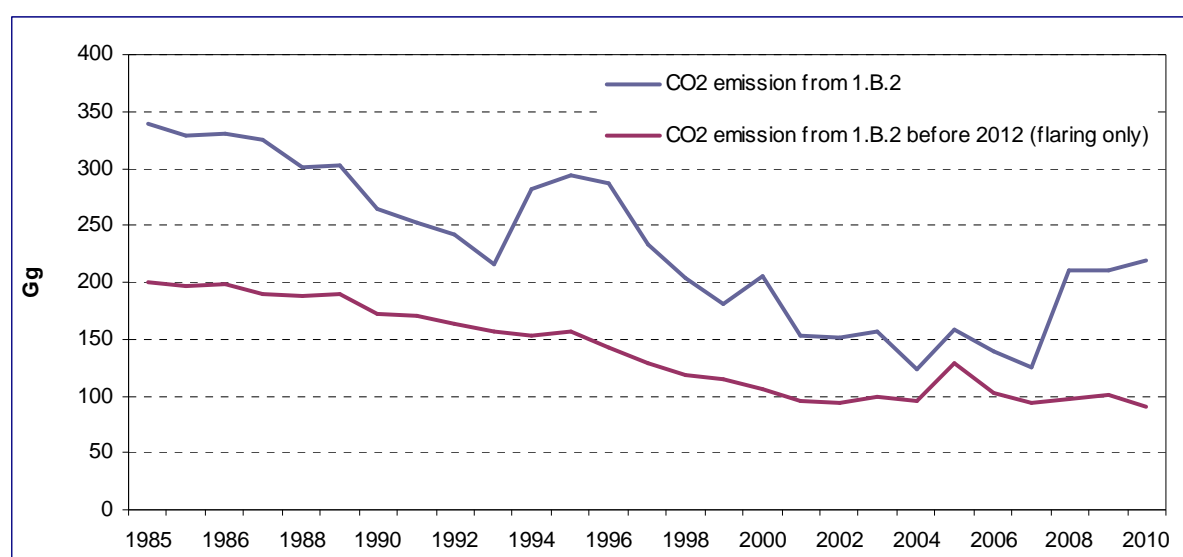
*Table 10.7. Change in CO<sub>2</sub> emissions from Energy 1.B.2 sector due to recalculations*

	1991	1992	1993	1994	1995	1996	1997
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	252.69	241.58	215.46	282.29	293.07	287.71	232.69
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	169.82	163.93	155.90	153.55	157.08	141.97	128.89

	1991	1992	1993	1994	1995	1996	1997
<b>Difference</b>	82.87	77.65	59.56	128.74	135.99	145.75	103.80
<b>Percentage change %</b>	148.80	147.37	138.20	183.84	186.57	202.66	180.54

	1998	1999	2000	2001	2002	2003	2004
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	203.05	180.85	205.36	152.67	150.97	157.19	124.03
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	118.89	114.29	105.49	94.89	93.49	99.69	94.93
<b>Difference</b>	84.16	66.55	99.87	57.78	57.48	57.49	29.10
<b>Percentage change %</b>	170.79	158.23	194.67	160.89	161.48	157.67	130.65

	2005	2006	2007	2008	2009	2010
<b>CO<sub>2</sub> emission from 1.B.2., (Gg)</b>	158.48	139.77	125.50	210.73	209.62	218.96
<b>CO<sub>2</sub> emission from 1.B.2 Submission before 2012 (flaring only):</b>	129.43	103.30	93.86	96.56	100.10	90.42
<b>Difference</b>	29.06	36.47	31.64	114.17	109.52	128.53
<b>Percentage change %</b>	122.45	135.30	133.71	218.24	209.42	242.15



**Figure 10.1.** Difference of CO<sub>2</sub> emissions due to recalculation in sector 1.B.2

## 10.3 Industry

All recalculations and reallocation in the industrial processes sector resulted in increase of emissions up to 42 % (See Table 10.8) ), which is mainly due to the reallocation from 1.A.2.a into 2.C.1 sub-sector.. Details of recalculations and reallocations can be found in the sub-chapters below.

**Table 10.8. Change in total GHG emissions from Industrial Processes sector**

INDUSTRY TOTAL GHG EMISSION (CO <sub>2</sub> eq, Gg)	Base year	1990	1995	2000	2002	2003	2004	2005	2006	2007	2008	2009
2011 submission	11021.8	8860.4	5467.9	6302.0	5591.9	5694.2	6515.5	7073.4	6498.8	6180.9	5058.9	4195.7
2012 submission	14637.4	11572.7	7853.7	8167.9	8038.5	7355.4	7225.3	8372.1	8863.1	8203.7	8067.4	6831.5
Change (%)	32.80	30.61	43.63	29.61	26.62	31.54	26.89	28.49	25.30	26.23	30.52	35.04
Difference (Gg)	3615.6	2712.3	2385.7	1865.8	1689.9	1763.5	1531.1	1856.5	1789.7	1704.8	1886.5	1772.6

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

In sector 2.A.7 – Other Mineral Products (Bricks and ceramics) activity data has been changed in submission year 2012. Activity data on total production of bricks and ceramics is provided by the HCSO every year. In 2008 HCSO switched from NACE1. to NACE2.2.classification of industrial products. It was discovered that due to this change the activity data in 2009 was incomplete and did not cover the full domestic production. This correction does not cause a change in emissions, since anyway ETS data is used in this sector, but the IEF of CO<sub>2</sub> has changed significantly to a better fitting value, as it is presented in Table 10.9.

**Table 10.9. Change in CO<sub>2</sub> IEF (t/t) emissions in Bricks and ceramics sector**

	2008	2009
Submission 2011	0.10529	0.17708
Submission 2012	0.07747	0.07432
Difference,	-0.03	-0.10
Percentage change	-26.4%	-58.0%

The activity data changed according to the following table:

**Table 10.10. Change in activity data (kt) in Bricks and ceramics sector**

	2008	2009
Submission 2011	2,962.756	622.224
Submission 2012	4,026.644	1,482.639
Difference, (kt)	1,063.89	860.42
Percentage change	35.9%	138.3%

Recalculation in 2.C.1. and 1.A.2.a

In 2012 submission the following improvements were performed in sector 2.C.1:

- Recalculation of the time series of 2.C.1.1 Steel due to correction of activity data;
- Reallocation of emissions between sector 1.A.2.a and 2.C.1.2 (Pig Iron production) and 2.C.1.4 (Coke consumption)
- Review of the amount of emission to be subtracted from consumption of coke in order to



avoid double count

- Recalculation of indirect GHGs using EMEP/EEA 2009 Guidebook default emission factors

*Recalculation of the time series of 2.C.1.1*

The recalculation of 2.C.1.1 is due to correction of activity data of EAF steel production (emissions from graphite electrode).

**Table 10.11 Change in CO<sub>2</sub> emission from 2.C.1.1 Steel sector**

		1985	BY	1986	1987	1988	1989	1990
2.C.1.1 Steel CO <sub>2</sub> Submission 2011	Gg	467.90	469.70	476.50	464.70	459.82	430.66	380.24
2.C.1.1 Steel CO <sub>2</sub> Submission 2012	Gg	470.16	471.98	478.84	466.94	461.90	432.67	382.04
Difference	Gg	2.26	2.28	2.34	2.25	2.08	2.01	1.79
Difference	%	0.48%	0.49%	0.49%	0.48%	0.45%	0.47%	0.47%
		1991	1992	1993	1994	1995	1996	1997
2.C.1.1 Steel CO <sub>2</sub> Submission 2011	Gg	247.68	197.76	224.97	248.71	238.83	240.24	218.49
2.C.1.1 Steel CO <sub>2</sub> Submission 2012	Gg	248.24	198.09	225.46	249.08	239.38	240.70	218.49
Difference	Gg	0.56	0.32	0.49	0.37	0.55	0.46	0.00
Difference	%	0.23%	0.16%	0.22%	0.15%	0.23%	0.19%	0.00%
		1998	1999	2000	2001	2002	2003	2004
2.C.1.1 Steel CO <sub>2</sub> Submission 2011	Gg	234.56	233.75	241.90	251.99	265.35	257.05	251.87
2.C.1.1 Steel CO <sub>2</sub> Submission 2012	Gg	234.56	233.76	241.28	251.98	265.34	257.01	251.92
Difference	Gg	0.00	0.00	-0.62	0.00	0.00	-0.04	0.05
Difference	%	0.00%	0.00%	-0.26%	0.00%	0.00%	-0.02%	0.02%
		2005	2006	2007	2008	2009	2010	
2.C.1.1 Steel CO <sub>2</sub> Submission 2011	Gg	253.51	269.63	290.10	271.60	180.44	n.a	
2.C.1.1 Steel CO <sub>2</sub> Submission 2012	Gg	253.50	269.61	290.10	271.60	180.44	215.82	
Difference	Gg	-0.01	-0.02	0.00	0.00	0.00	n.a	
Difference	%	0.00%	-0.01%	0.00%	0.00%	0.00%	n.a	

*Reallocation of emissions between sector 1.A.2.a and 2.C.1.2 (Pig Iron production) and 2.C.1.4 (Coke consumption)*

The reallocation of emissions between energy and industry sectors is due to the recommendation of the review report of the 2011 submission. In paragraph 61. ERT recommends that Hungary allocate the emissions from use of coke as a reducing agent in blast furnaces to the industrial processes sector. Fortunately the consumption of coke in blast furnaces is now reported in the IEA Energy statistics in Hungary, so it is possible now to execute the division. Emission from the use of coke in the blast furnaces is reported in 2.C.1.4 and emissions from the use of natural gas in the blast furnace (as reducing agent or other non-energy use) is reported in 2.C.1.2. Both CO<sub>2</sub> and CH<sub>4</sub> emissions are reported using kg /TJ emission factors from the energy sector in order to achieve more accurate result by using actual plant specific data of the year.

It is worth mentioning that all cell comment of IE notes have also been updated as it is presented in the following Table 10.12, where the allocation of emissions connected to Iron and steel production is summarized following the order of the process.



**Table 10.12** Changes in allocation of emissions from Iron and steel industry

<b>IPCC sector code</b>	<b>Activity</b>	<b>Emission source</b>	<b>2011 submission -Emission reported in</b>	<b>2012 submission -Emission reported in</b>
1.A.1.c	Production of coke	combustion	1.A.1.c	1.A.1.c
1.A.2.a	Combustion needed for iron and steel production	combustion	1.A.2.a	1.A.2.a (including coke oven gas)
2.C.1.3	Sinter	Metal roasting	Included in 1.A.2.a	Included in 2.C.1.1
		limestone and dolomite use	Included in 2.A.3	Included in 2.A.3
2.C.1.2	Pig Iron	Combustion	Included in 1.A.2.a	Included in 1.A.2.a
		Consumption of coke	Included in 1.A.2.a	Included in 2.C.1.4
		Consumption of Natural gas for non-energy purposes	Included in 1.A.2.a	2.C.1.2
		limestone and dolomite use	Included in 2.A.3	IE to 2.A.3
2.C.1.4.	Consumption of coke	Consumption of coke in the blast furnace	Included in 1.A.2.a	2.C.1.4.
2.C.1.1	Steel	reduction of carbon content (from 4% to 0,5%)	2.C.1.1.	2.C.1.1.
		emission from graphite electrode during EAF steel production	2.C.1.1.	2.C.1.1.

**Table 10.13.** Emissions in 2.C.1.4 sector in 2012 submission

		<b>1985</b>	<b>BY</b>	<b>1986</b>	<b>1987</b>	<b>1988</b>	<b>1989</b>	<b>1990</b>
<b>Consumption of coke in blast furnace</b>	<b>kt</b>	1 449	1368,5	1 406	1 250	1 238	1 086	1 040
<b>Consumption of coke in blast furnace</b>	<b>TJ</b>	39678	37966	38918	35301	34752	30353	28 220
<b>CO2 emission in 2.C.1.4</b>	<b>Gg</b>	3 796	3 613	3 709	3 335	3 278	2 839	2 657
<b>CH4 emission in 2.C.1.4</b>	<b>Gg</b>	0,3968	0,3797	0,3892	0,3530	0,3475	0,3035	0,2822
		<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
<b>Consumption of coke in blast furnace</b>	<b>kt</b>	737	656	778	891	870	815	562
<b>Consumption of coke in blast furnace</b>	<b>TJ</b>	19 998	17 801	21 137	24 207	23 636	22 142	16 337
<b>CO2 emission in 2.C.1.4</b>	<b>Gg</b>	1 887	1 697	2 028	2 327	2 281	2 119	1 556
<b>CH4 emission in 2.C.1.4</b>	<b>Gg</b>	0,2000	0,1780	0,2114	0,2421	0,2364	0,2214	0,1634
		<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>
<b>Consumption of coke in blast furnace</b>	<b>kt</b>	597	590	639	566	606	549	570
<b>Consumption of coke in blast furnace</b>	<b>TJ</b>	17 654	17 504	19 022	16 849	18 068	16 211	16 736

<b>CO<sub>2</sub> emission in 2.C.1.4</b>	<b>Gg</b>	1 677	1 651	1 806	1 567	1 703	1 508	1 560
<b>CH<sub>4</sub> emission in 2.C.1.4</b>	<b>Gg</b>	0,1765	0,1750	0,1902	0,1685	0,1807	0,1621	0,1674
		<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	
<b>Consumption of coke in blast furnace</b>	<b>kt</b>	596	601	620	599	593	686	
<b>Consumption of coke in blast furnace</b>	<b>TJ</b>	17 403	17 723	18 271	17 641	17 571	20 484	
<b>CO<sub>2</sub> emission in 2.C.1.4</b>	<b>Gg</b>	1 633	1 667	1 714	1 649	1 695	1 953	
<b>CH<sub>4</sub> emission in 2.C.1.4</b>	<b>Gg</b>	0,1740	0,1772	0,1827	0,1764	0,1757	0,2048	

*Review of the amount of emission to be subtracted from consumption of coke in order to avoid double counting*

Carbon content of the pig iron is originating on one hand from the coke and on the other hand from the original carbon content of the iron ore. Pig iron as the input material for BOF (basic oxygen furnace) steel production has a carbon content of 4%, of which 0,5% is remaining in the steel. So, the CO<sub>2</sub> emission calculated from the reduction from 4% to 0,5% = 3,5 % is reported in 2.C.1.1 (steel).

In order to avoid double counting the emissions calculated this way should be subtracted from subsector 2.C.1.4. (Coke consumption). However, instead of the total 4% (as 0,5% remaining in the steel is also not emitted into the atmosphere) still the 3,5%% is subtracted in order to compensate the carbon content of the pig iron coming from the original carbon content of the iron ore, which is 0,5% in average. (Of course the original carbon content of the ore is usually eliminated during sintering but it is reported here together for simplification.)

In the case of EAF steel production the input material is usually scrap iron and other unknown material. These feedstock do contain carbon but it is not originating directly from the use of coke of the blast furnace of the given year. So, EAF steel production is included in „Steel produced (kt)” data of the formula above, but the carbon content reduction of EAF steel production is not subtracted from 2.C.1.4 Consumption of coke.

*Recalculation of indirect GHGs using EMEP/EEA 2009 Guidebook default emission factors*

Before 2012 submission the reporting of indirect GHGs was not complete and not consistent with CLRTAP reporting. As EMEP/EEA 2009 Guidebook contains more up to date default emission factors for NO<sub>x</sub>, CO and NMVOC, both reporting was recalculated using these factors.

**Table 10.14. Change in emission of indirect GHGs in sector 2.C.1**

		<b>1985</b>	<b>BY</b>	<b>1986</b>	<b>1987</b>	<b>1988</b>	<b>1989</b>	<b>1990</b>
<b>NO<sub>x</sub> Submission 2011</b>	Gg	IE	IE	IE	IE	IE	IE	IE
<b>CO Submission 2011</b>	Gg	171.08	171.21	171.86	170.69	169.15	158.24	139.05
<b>NMVOC Submission 2011</b>	Gg	0.57	0.5733	0.58	0.57	0.5676	0.531	0.4666
<b>NO<sub>x</sub> Submission 2012</b>	Gg	0.0720	0.0739	0.0752	0.0745	0.0706	0.0678	0.0609
<b>CO Submission 2012</b>	Gg	5.3881	5.8718	5.8116	6.4157	6.5003	6.0756	5.5976
<b>NMVOC Submission 2012</b>	Gg	0.55	0.55	0.56	0.54	0.54	0.50	0.44
		<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
<b>NO<sub>x</sub> Submission 2011</b>	Gg	IE	IE	IE	IE	IE	IE	IE
<b>CO Submission 2011</b>	Gg	96.671	80.967	94.168	97.953	95.807	101.62	94.436
<b>NMVOC Submission 2011</b>	Gg	0.3244	0.2717	0.316	0.3287	0.3215	0.341	0.3169

<b>NOx Submission 2012</b>	Gg	0.0278	0.0218	0.0293	0.0282	0.0318	0.0297	0.0554
<b>CO Submission 2012</b>	Gg	4.8175	4.7916	5.9588	6.6504	6.3159	6.3869	5.3370
<b>NMVOC Submission 2012</b>	Gg	0.29	0.23	0.26	0.29	0.28	0.28	0.25
		<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>
<b>NOx Submission 2011</b>	Gg	IE	IE	IE	IE	IE	IE	IE
<b>CO Submission 2011</b>	Gg	98.042	23.569	39.942	36.535	39.771	39.72	40.26
<b>NMVOC Submission 2011</b>	Gg	0.329	0.1813	0.134	0.1226	0.1335	0.1335	0.1351
<b>NOx Submission 2012</b>	Gg	0.0543	0.0442	0.0468	0.0489	0.0685	0.0619	0.0535
<b>CO Submission 2012</b>	Gg	5.8134	5.9539	6.1275	6.3994	6.4617	6.3314	6.3225
<b>NMVOC Submission 2012</b>	Gg	0.27	0.27	0.28	0.29	0.31	0.30	0.29
		<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	
<b>NOx Submission 2011</b>	Gg	IE	IE	IE	IE	IE	IE	
<b>CO Submission 2011</b>	Gg	39.61	39.826	41.554	38.405	31.291	39.492	
<b>NMVOC Submission 2011</b>	Gg	0.1329	0.1336	0.1394	0.1289	0.105	0.1325	
<b>NOx Submission 2012</b>	Gg	0.0576	0.0729	0.0826	0.0838	0.0296	0.0591	
<b>CO Submission 2012</b>	Gg	6.3016	6.5138	6.9399	6.3935	4.6700	5.2380	
<b>NMVOC Submission 2012</b>	Gg	0.29	0.31	0.34	0.31	0.21	0.25	

#### *Further changes in 1.A.2.a*

In 2012 submission coke oven gas as a fuel was added to 1.A.2.a for the entire time series as it is described in chapter 10.2.3 above.

Regarding blast furnace gas please note that it should not be reported as an emission source in addition to coke and natural gas consumption reported in 2.C.1 subsector, since the carbon content of the blast furnace gas is from the coke or natural gas used in the blast furnace reported entirely in sector 2.C.1.4 and 2.C.1.2 respectively. That is why blast furnace gas is not reported in Energy sector.

#### *Comparison of allocation used in 2011 and 2012*

The following table proof that the TOTAL emissions connected to Iron and steel did not change due to the reallocation. The difference is due to two issues explained in the above sub-chapters, as it is noted in the Table.

Although 1.A.2.b is not connected to Iron and steel emissions, it is needed to include in this table, because 1.A.2.b was included (IE) in 1.A.2.a in submission 2011.

Please note that the years are chosen randomly for presentation in order to limit the size of the table. The justification of the difference is fulfilled for the whole time series.

**Table 10.15.** Comparison of Total CO<sub>2</sub> emission from Iron and steel production in 2011 and 2012 submission

	<b>BY</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>
<b>Total CO2 emissions (Gg) from sectors 1.A.2.a+1.A.2.b + 2.C.1 - Submission 2011</b>	8082.10	5577.25	3880.04	2768.99	2848.78	2851.67	2364.64
<b>Total CO2 emissions (Gg) from sectors 1.A.2.a+1.A.2.b + 2.C.1 - Submission 2012</b>	8200.41	5746.62	4064.52	2930.66	2965.96	2921.48	2381.94
<b>Difference (Gg)</b>	<b>118.31</b>	<b>169.37</b>	<b>184.49</b>	<b>161.67</b>	<b>117.18</b>	<b>69.81</b>	<b>17.29</b>
<b>Difference %</b>	<b>1.46%</b>	<b>3.04%</b>	<b>4.75%</b>	<b>5.84%</b>	<b>4.11%</b>	<b>2.45%</b>	<b>0.73%</b>

<i>Justification of difference:</i>							
<b>CO2 emission from coke oven gas allocated to 1.A.2.a (Gg) <sup>1</sup></b>	57.47	121.95	169.85	130.49	75.04	<i>Already included in 1.A.2.a</i>	<i>Already included in 1.A.2.a</i>
<b>CO2 emissions due to carbon content reduction of EAF steel production (Gg) <sup>2</sup></b>	60.84	47.42	14.64	31.18	42.14	69.81	17.29
<b>SZUM (Gg)</b>	<b>118.31</b>	<b>169.37</b>	<b>184.49</b>	<b>161.67</b>	<b>117.18</b>	<b>69.81</b>	<b>17.29</b>

1: Due to the issue explained above by "Further changes in 1.A.2.a"

2: Due to the issue explained above by "Review of the subtraction from consumption of coke"

### 10.3.2 2.F. Consumption of Halocarbons and SF<sub>6</sub> (CRF sector 2.F)

In 2012 submission subsector 2.F.1.1 was recalculated due to the inclusion of Product Manufacturing Factor (PMF). For details, please see chapter 4.8.3.1.

**Table 10.16.** Change in emission of HFCs due to recalculation in 2.F.1.1 sector

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
<b>HFC actual emission 2011 submission (Gg CO2 eq)</b>	0.10	0.10	0.52	0.74	3.37	68.92	163.14	376.51	217.19	311.71
<b>HFC actual emission 2012 submission (Gg CO2 eq)</b>	0.10	0.10	0.52	0.74	3.44	69.29	163.76	377.42	218.27	312.93
<b>Difference (Gg CO2 eq)</b>	0.00	0.00	0.00	0.00	0.07	0.37	0.62	0.91	1.08	1.22
<b>Difference %</b>	0.00%	0.00%	0.00%	0.00%	2.01%	0.53%	0.38%	0.24%	0.50%	0.39%
	2002	2003	2004	2005	2006	2007	2008	2009	2010	
<b>HFC actual emission 2011 submission (Gg CO2 eq)</b>	386.81	490.69	541.81	554.82	623.25	752.96	857.49	776.12	n.a.	
<b>HFC actual emission 2012 submission (Gg CO2 eq)</b>	388.59	492.64	544.21	557.17	626.22	756.57	861.70	779.81	866.33	
<b>Difference (Gg CO2 eq)</b>	1.78	1.96	2.39	2.35	2.97	3.61	4.21	3.69	n.a.	
<b>Difference %</b>	0.46%	0.40%	0.44%	0.42%	0.48%	0.48%	0.49%	0.48%	n.a.	

**Table 10.17.** Change in emission of PFCs due to recalculation in 2.F.1.1 sector

	1995	1996	1997	1998	1999	2000	2001	2002
<b>PFC actual emission 2011 submission (Gg CO2 eq)</b>	NO	NO	0.04	0.65	0.73	0.53	0.64	0.86
<b>PFC actual emission 2012 submission (Gg CO2 eq)</b>	NO	NO	0.05	0.66	0.75	0.54	0.65	0.88
<b>Difference (Gg CO2 eq)</b>	NO	NO	0.00	0.01	0.02	0.01	0.01	0.02
<b>Difference %</b>	NO	NO	2.33%	2.16%	2.33%	2.33%	1.89%	1.95%
	2003	2004	2005	2006	2007	2008	2009	2010
<b>PFC actual emission 2011 submission (Gg CO2 eq)</b>	1.31	1.11	1.55	1.59	2.38	2.41	1.72	n.a.
<b>PFC actual emission 2012 submission (Gg CO2 eq)</b>	1.32	1.12	1.57	1.60	2.40	2.43	1.74	0.36
<b>Difference (Gg CO2 eq)</b>	0.02	0.01	0.01	0.02	0.02	0.02	0.02	n.a.
<b>Difference %</b>	1.25%	1.09%	0.92%	0.95%	0.87%	0.88%	1.04%	n.a.

In addition, in this year a comprehensive checking was carried out in 2.F.8 and 2.F.9 sub-sector. All activity data has been verified and all calculations from the year 1985 has been updated. The calculation and copying errors were corrected. Besides, new data were added to 2.F.8 sub-sector: One of the manufacturers using SF<sub>6</sub>, representing around 10% of SF<sub>6</sub> use, did not report for the years between 2006 and 2008. Activity data were extrapolated from the previous 2 years. Thanks to government decree 345/2009 on the data provision of HMS, we could collect the missing data eventually, so we recalculated the emissions. These recalculations resulted in an increase of emissions, as shown in *Table 10.18,- Table 22*.

**Table 10.18. Changes in 2.F.8 sub-sector in actual emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	4.203	3.390	3.236	2.731	3.500	1.028	1.668
Submission 2012 (t )	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference, (t )	-0.50	-0.33	-0.50	0.00	0.00	2.00	2.00
Percentage change	-11.90%	-9.83%	-15.45%	0.00%	0.00%	194.36%	119.78%
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	2.206	1.549	1.467	1.843	1.435	1.087	1.551
Submission 2012 (t )	4.289	3.660	4.733	5.255	5.596	5.507	6.251
Difference, (t )	2.083	2.111	3.266	3.412	4.161	4.420	4.700
Percentage change	94.4%	136.2%	222.6%	185.1%	290.0%	406.6%	303.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	1.455	4.816	5.282	3.785	4.232	5.135	5.445
Submission 2012 (t )	4.216	7.608	7.090	8.247	6.022	5.873	11.782
Difference, (t )	2.761	2.792	1.808	4.462	1.790	0.738	6.337
Percentage change	189.8%	58.0%	34.2%	117.9%	42.3%	14.4%	116.4%
	2005	2006	2007	2008	2009		
Submission 2011 (t )	6.303	6.767	4.800	8.075	8.532		
Submission 2012 (t )	7.767	4.208	8.192	9.900	8.569		
Difference, (t )	1.464	-2.559	3.392	1.825	0.037		
Percentage change	23.2%	-37.8%	70.7%	22.6%	0.4%		

**Table 10.19. Changes in 2.F.8 sub-sector in potential emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (Gg)	0.00420	0.00339	0.00324	0.00273	0.00350	0.00326	0.00367
Submission 2012 (Gg)	0.00370	0.00306	0.00274	0.00273	0.00350	0.00303	0.00367
Difference (Gg)	-0.00050	-0.00033	-0.00050	0.00000	0.00000	-0.00023	0.00000
Percentage change	-11.9%	-9.8%	-15.5%	0.0%	0.0%	-7.2%	0.0%
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (Gg)	0.00420	0.00355	0.00446	0.00484	0.00543	0.00508	0.00555
Submission 2012 (Gg)	0.00429	0.00366	0.00473	0.00526	0.00560	0.00551	0.00682
Difference (Gg)	0.00008	0.00011	0.00027	0.00042	0.00017	0.00042	0.00128

Percentage change	2.0%	3.2%	6.0%	8.6%	3.0%	8.3%	23.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (Gg)	0.00409	0.00729	0.00633	0.00793	0.00644	0.00557	0.00926
Submission 2012 (Gg)	0.00469	0.00761	0.00709	0.00825	0.00696	0.00587	0.01318
Difference (Gg)	0.00060	0.00031	0.00076	0.00032	0.00052	0.00031	0.00392
Percentage change	14.6%	4.3%	12.0%	4.0%	8.1%	5.5%	42.4%
	2005	2006	2007	2008	2009		
Submission 2011 (Gg)	0.00775	0.00394	0.00623	0.01069	0.00812		
Submission 2012 (Gg)	0.00775	0.00427	0.00799	0.00949	0.00816		
Difference (Gg)	0.00000	0.00033	0.00176	-0.00120	0.00004		
Percentage change	0.0%	8.3%	28.3%	-11.2%	0.5%		

**Table 10.20.. Changes in 2.F.9 sub-sector in actual=potential emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	NO	NO	NO	NO	NO	NO	NO
Submission 2012 (t )	NO	NO	NO	NO	NO	NO	NO
Difference, (t )	-	-	-	-	-	-	-
Percentage change	-	-	-	-	-	-	-
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	NO	0.50000	0.70000	1.00000	1.50000	1.80000	1.29500
Submission 2012 (t )	NO	0.50000	0.70000	1.00000	1.50000	1.80000	2.59000
Difference, (t )	-	0.000	0.000	0.000	0.000	0.000	1.295
Percentage change	-	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	1.41000	0.49000	0.58000	0.71000	0.77000	1.64000	2.01000
Submission 2012 (t )	2.82000	0.99000	1.08000	1.21000	1.27000	1.64000	2.01000
Difference, (t )	1.410	0.500	0.500	0.500	0.500	0.000	0.000
Percentage change	100.0%	102.0%	86.2%	70.4%	64.9%	0.0%	0.0%
	2005	2006	2007	2008	2009		
Submission 2011 (t )	2.10800	3.46100	2.38200	1.62790	0.65880		
Submission 2012 (t )	2.18000	3.56500	2.38240	1.62790	0.65880		
Difference, (t )	0.072	0.104	0.000	0.000	0.000		
Percentage change	3.4%	3.0%	0.0%	0.0%	0.0%		

**Table 10.21.. Changes in 2.F.8-9 sub-sector in actual emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	4.203	3.390	3.236	2.731	3.500	1.028	1.668
Submission 2012 (t )	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference, (t )	-0.500	-0.333	-0.500	0.000	0.000	1.998	1.998
Percentage change	-0.12	-0.10	-0.15	0.00	0.00	1.94	1.20

	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	2.206	2.049	2.167	2.843	2.935	2.887	2.846
Submission 2012 (t )	4.289	4.160	5.433	6.255	7.096	7.307	8.841
Difference, (t )	2.083	2.111	3.266	3.412	4.161	4.420	5.995
Percentage change	0.94	1.03	1.51	1.20	1.42	1.53	2.11
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	2.865	5.306	5.862	4.495	5.002	6.775	7.455
Submission 2012 (t )	7.036	8.598	8.170	9.457	7.292	7.513	13.792
Difference, (t )	4.171	3.292	2.308	4.962	2.290	0.738	6.337
Percentage change	1.46	0.62	0.39	1.10	0.46	0.11	0.85
	2005	2006	2007	2008	2009		
Submission 2011 (t )	8.411	10.228	7.182	9.702	9.191		
Submission 2012 (t )	9.947	7.773	10.574	11.527	9.228		
Difference, (t )	1.536	-2.455	3.392	1.825	0.037		
Percentage change	0.18	-0.24	0.47	0.19	0.00		

**Table 10.22. Changes in 2.F.8-9 sub-sector in potential emission (1985-2009)**

	1985	BY	1986	1987	1988	1989	1990
Submission 2011 (t )	4.203	3.390	3.236	2.730	3.506	3.026	3.666
Submission 2012 (t )	3.703	3.057	2.736	2.731	3.500	3.026	3.666
Difference (t )	-0.500	-0.333	-0.500	0.001	-0.006	0.000	0.000
Percentage change	-0.12	-0.10	-0.15	0.00	0.00	0.00	0.00
	1991	1992	1993	1994	1995	1996	1997
Submission 2011 (t )	4.204	4.047	5.164	5.840	6.931	6.883	8.137
Submission 2012 (t )	4.289	4.160	5.433	6.255	7.096	7.307	9.415
Difference (t )	0.085	0.113	0.269	0.415	0.165	0.424	1.278
Percentage change	0.02	0.03	0.05	0.07	0.02	0.06	0.16
	1998	1999	2000	2001	2002	2003	2004
Submission 2011 (t )	6.910	7.784	7.308	8.241	7.211	7.207	13.468
Submission 2012 (t )	7.507	8.098	7.670	8.957	7.732	7.513	15.192
Difference (t )	0.597	0.314	0.362	0.716	0.521	0.306	1.724
Percentage change	0.09	0.04	0.05	0.09	0.07	0.04	0.13
	2005	2006	2007	2008	2009		
Submission 2011 (t )	9.928	8.566	11.218	12.570	9.997		
Submission 2012 (t )	9.928	7.836	10.372	11.120	8.815		
Difference (t )	0.000	-0.731	-0.846	-1.451	-1.181		
Percentage change	0.00	-0.09	-0.08	-0.12	-0.12		



### 10.3.3 *Feedstock and non energy use of fuels (CRF sector 2.G)*

In 2012 submission activity data of year 2009 was recalculated due to the review of amount of natural gas feedstock not included in other industrial processes subsectors.

There was a difference of 669 TJ natural gas used in the Industrial Processes subsector and the natural gas as a feedstock item of the Hungarian Energy Statistics for the year 2009. This amount results 26 Gg CO<sub>2</sub> emission, which was included in sector 2.G.

*Table 10.23. Change in emission of year 2009 in 2.G sector*

	2009
CO2 emission from sector 2.G Submission 2011 (Gg)	854.87
CO2 emission from sector 2.G Submission 2012 (Gg)	881.14
Difference (Gg)	26.27
Difference %	3.07%

## 10.4 Agriculture sector

In the period 2000-2008 HCSO had produced three censuses of animal numbers per year. Since 2009 HCSO has been collected livestock population twice a year. In some cases these detailed livestock statistics were revised by the HCSO, but data revision has not yet been taken into account in the GHG inventory. Recently, the HCSO provided the revised livestock population data for the HMS, for the period 2000-2009. The detailed livestock population data used in the GHG inventory were checked and revised according to the latest HCSO's statistics.

In the GHG inventory the annual average livestock population of dairy cattle is taken into account according to the HCSO's statistics used to calculate the annual average milk yield per cow to insure the consistency between the two databases. In the course of the annual QC procedure this time series of annual average livestock population were compared with the original data of HCSO's annual censuses. The result of this comparison revealed that there is inconsistency between the animal numbers used to calculate the average annual milk yield per cow and the data of censuses for the period 1985-2003. HMS initiated a discussion with the HCSO to solve this problem. It turned out that the main reason of the inconsistency was the methodology of calculation of annual average from the data of censuses. The HCSO had calculated the annual average livestock population in an inconsistent manner for the period 1985-2003. Chronological means have been used to calculate the annual livestock population by the HCSO since 2004, but revision has not yet been made for the former years. In addition, beef cows were categorized as dairy cattle for the years 2000 and 2001.

The HCSO has revised the annual average dairy cattle population and the annual average milk yield statistics for the period 1985-2003, using chronological means, consequently. The livestock population and milk yield statistics in the GHG inventory were corrected in accordance with the HCSO's revised data.

For the other livestock categories the chronological mean has been applied to determine the annual average livestock population since the 2004 inventory year in accordance with the HCSO's practice. The HCSO suggested using the chronological mean for the whole time

series for all livestock categories, for which data is available. Therefore, cattle and swine livestock population were revised to use chronological mean for the period 1985-2003, while livestock population of sheep, goats, horses, asses and mules, poultry and rabbits were recalculated for the period 2000-2003. Chronological means cannot be applied for the latter livestock categories before 2000, because survey was taken place only once a year in the period 1985-1999.

The chronological means were applied for the different sub-categories of non-dairy cattle and swine as well. The correction of the animal number of the subcategories for non-dairy cattle resulted changes of the gross energy intake thus the country specific emission factor for enteric fermentation and CH<sub>4</sub> emission from manure management and N-excretion rate. In the case of swine the time series of the N-excretion rate was needed to recalculate according to changes of detailed animal numbers.

Following the recommendations from the in-country review of Hungary's 2010 submission, the gross energy intake for dairy cattle and N-excretion rate for swine were revised. Revision was made according to the change of the annual average milk yield and the corrected enhanced livestock characterization. In the case of the dairy cattle a new dataset on fat content of milk was also applied for the period 1998-2009. (Due to lack of this dataset, expert judgment was applied, previously.)

Allocation of swine manure produced in pits was revised as an outcome of the in-country review of 2010 submission. Swine manure in 'Pit storage<1 month' and 'Pit storage>1 month' are now reported separately from the liquid manure. They are allocated to the 'Other' animal waste management system and for the methane conversion factor (MCF) the weighted average is now reported in accordance with the ERT encouragement.

In the course of the annual QC process an error was recognized in the calculation sheet for volatile solid excretion rate for poultry. The error has been corrected and the time-series of CH<sub>4</sub> emissions from manure management for poultry has been recalculated.

Research project on the development of country specific parameters for the estimation of N-input from crop residues of oilseed rape and sunflower has finished. The results of this research were applied for the first time in the 2012 submission.

Table 10.24, Table 10.25 and Table 10.26 outline the net effect of recalculations for the period 1985-2009 by greenhouse gas. The net effect on total GHG emissions are an increase of 0.04 per cent in 1996 to 2.64 per cent in 1996, and a decrease of 0.06 percent in 2000 and 2005 to 0.46 per cent in 1995. The greatest changes are for CH<sub>4</sub> emissions due to higher impact of the revisions for category 4.A Enteric Fermentation. The effects of other recalculations are smaller and they resulted in an increase for some years and a decrease for others.

**Table 10.24** *Change in total GHG emissions from Agriculture sector due to recalculations*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CO <sub>2</sub> -eq]	17,550	17,449	17,552	17,647	17,144	16,539	14,555	11,765	10,132
Submission 2012 [Gg CO <sub>2</sub> -eq]	17,946	17,910	17,905	18,025	17,487	16,889	14,524	11,893	10,257
Difference [Gg CO <sub>2</sub> -eq]	397	460	353	377	344	350	-31	128	125
Percentage change	2.3%	2.6%	2.0%	2.1%	2.0%	2.1%	-0.2%	1.1%	1.2%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CO <sub>2</sub> -eq]	9,077	8,984	8,725	8,856	8,663	9,223	9,401	9,124	9,355
Submission 2012 [Gg CO <sub>2</sub> -eq]	9,142	9,039	8,684	8,860	8,701	9,185	9,397	9,118	9,332
Difference [Gg CO <sub>2</sub> -eq]	65	55	-40	4	37	-38	-4	-6	-23
Percentage change	0.7%	0.6%	-0.5%	0.0%	0.4%	-0.4%	0.0%	-0.1%	-0.2%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CO <sub>2</sub> -eq]	9,499	9,268	9,380	8,853	8,899	8,953	8,830	8,310	
Submission 2012 [Gg CO <sub>2</sub> -eq]	9,503	9,249	9,397	8,848	8,898	8,955	8,812	8,295	
Difference [Gg CO <sub>2</sub> -eq]	4	-19	17	-5	-1	2	-18	-15	
Percentage change	0.0%	-0.2%	0.2%	-0.1%	0.0%	0.0%	-0.2%	-0.2%	

**Table 10.25** *Change in CH<sub>4</sub> emissions from Agriculture sector due to recalculation*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg CH <sub>4</sub> ]	284	289	283	279	277	266	271	243	206
Submission 2012 [Gg CH <sub>4</sub> ]	293	301	291	288	285	276	269	247	209
Difference [Gg CH <sub>4</sub> ]	10	11	8	9	8	9	-1	4	2
Percentage change	3.4%	3.9%	2.9%	3.4%	2.8%	3.4%	-0.5%	1.6%	1.2%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg CH <sub>4</sub> ]	181	159	160	164	155	161	163	158	152
Submission 2012 [Gg CH <sub>4</sub> ]	183	161	159	163	157	159	163	160	152
Difference [Gg CH <sub>4</sub> ]	2	2	-1	0	1	-1	0	1	0
Percentage change	0.9%	1.0%	-0.7%	-0.2%	0.9%	-0.8%	0.2%	0.8%	0.2%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg CH <sub>4</sub> ]	154	153	143	137	134	135	129	123	
Submission 2012 [Gg CH <sub>4</sub> ]	154	153	143	137	134	136	129	123	
Difference [Gg CH <sub>4</sub> ]	0	0	0	0	0	1	0	0	
Percentage change	0.1%	0.2%	0.3%	0.1%	0.3%	0.7%	0.2%	0.3%	

**Table 10.26** *Change in N<sub>2</sub>O emissions from Agriculture sector due to recalculation*

	BY	1985	1986	1987	1988	1989	1990	1991	1992
Submission 2011 [Gg N <sub>2</sub> O]	37.39	36.69	37.44	38.04	36.54	35.30	28.62	21.46	18.71
Submission 2012 [Gg N <sub>2</sub> O]	38.02	37.40	38.02	38.62	37.13	35.81	28.62	21.61	18.95
Difference [Gg N <sub>2</sub> O]	0.63	0.71	0.58	0.58	0.59	0.51	0.00	0.14	0.24
Percentage change	1.7%	1.9%	1.6%	1.5%	1.6%	1.5%	0.0%	0.7%	1.3%
	1993	1994	1995	1996	1997	1998	1999	2000	2001
Submission 2011 [Gg N <sub>2</sub> O]	17.00	18.18	17.28	17.48	17.43	18.87	19.30	18.71	19.87
Submission 2012 [Gg N <sub>2</sub> O]	17.10	18.25	17.22	17.51	17.46	18.84	19.26	18.60	19.78
Difference [Gg N <sub>2</sub> O]	0.10	0.07	-0.05	0.03	0.03	-0.03	-0.04	-0.11	-0.09
Percentage change	0.6%	0.4%	-0.3%	0.2%	0.1%	-0.2%	-0.2%	-0.6%	-0.5%
	2002	2003	2004	2005	2006	2007	2008	2009	
Submission 2011 [Gg N <sub>2</sub> O]	20.23	19.56	20.59	19.25	19.65	19.76	19.73	18.48	
Submission 2012 [Gg N <sub>2</sub> O]	20.23	19.48	20.61	19.23	19.62	19.71	19.66	18.41	
Difference [Gg N <sub>2</sub> O]	0.00	-0.08	0.02	-0.02	-0.03	-0.06	-0.07	-0.07	
Percentage change	0.0%	-0.4%	0.1%	-0.1%	-0.2%	-0.3%	-0.4%	-0.4%	

## 10.5 LULUCF Sector

Main reasons leading to recalculations in the LULUCF sector for the whole time-series are as follows:

1. In accordance with the ERT recommendation the 5.A.2 Land converted to Forest Land category was revised, and the 20-year transition period has been already applied in accordance with the IPCC methodology. The allocation of these emissions/removals was also revised. All of the emissions/removals were previously reported in the 5.A.2.1 Cropland converted to Forest Land, and now reported separately by former land uses.
2. Emissions from dolomite use were revised as an outcome of the centralized review of the 2011 submission. The emission factor based on the stoichiometric formula of dolomite was used instead of the emission factor provided by the GPG for LULUCF (IPCC, 2003).
3. New data from the HCSO's General Agricultural Census, 2010 resulted in reconsideration of the applied activity data on management practices of mineral soils for the period 1998-2009.
4. In accordance with the ERT suggestion the allocation was also revised relating to the carbon stock change in living woody biomass on Cropland for the whole time-series. Emissions from removals of woody croplands taking into account in the 'land converted to' categories instead of a 'remaining' category resulted in minor methodological change in the estimation of emissions, because the 'gain' in the carbon stock of the living biomass in the new land-use category (grassland) were

formerly omitted and now estimated. As another consequence of this recalculation emissions/removals from conversions of annual croplands were also revised. (Up to 2011 submission a steady ratio of the annual and perennial 'cropland converted to' areas were assumed periodically, but now these areas were determined as a function of the removal of perennial cropland areas.) The effect of the revision of emissions from conversions of annual croplands to other land-uses, and the previously omitted gain in carbon stock of perennial croplands converted to grassland are summarized in **Table 7.50**.

5. Some minor changes relating to the area data as a result of the annual QC procedure were also made:
  - a. The former land-use categories of afforested areas were corrected in the period 2007-2009 according to the NFI data.
  - b. Rounding error in HCSO's removal statistics for orchard and vineyard were corrected for the period 2007-2009 and a transcription error in the calculation sheet for 2006 were also corrected.
  - c. The estimated area of the different management practices of Grassland (HAC soils in cold climate zone) were corrected for 2005, and 2009.

The impact of recalculations was generally an increase of removals up to 298 Gg CO<sub>2</sub> in 2009, but removals slightly decreased in some other years (in the period 1987-1990 and in 2007). The percentage change was the highest in 1985, because of the low level of removals. The main drivers behind these changes were the decrease in carbon losses in annual cropland conversions, and the inclusion of gain in the carbon stock of perennial cropland converted to grassland (Table 7.50) for the early years of the time-series 1985-2009. Changes in the removals in the latter years also reflect the effect of revision of emissions from mineral soils which resulted in higher changes in the removals. The effect of recalculation of lime application is negligible. Net effect of recalculations is shown in *Table 7.51*.

## 10.6 Waste sector

It has been a sharp difference in the time series up to 2001 and from 2002. As we considered the data for the recent years more accurate since they were based on more detailed background information, the first part of the time series needed to be amended to ensure consistency. First of all, the activity data, i.e. total organic product, were revisited based on total wastewater information. The average DC/unit wastewater representative for the early 2000's was 1.16 Gg COD/million m<sup>3</sup>. This average value was used back to 1988. For the previous three years, the same DC value was kept because wastewater amount showed a large increase most probably due to high wastewater output from the iron and steel industry that usually produces wastewater with low organic waste content. Although this might be considered as a somewhat rough estimate, we still believe that the recalculated time series is far more accurate and definitely more consistent than the previous one. The results are summarized in Table 10.27.

*Table 10.27 Changes due to recalculation in the industrial wastewater category*

	ORIGINAL		NEW		difference	
	Gg DC	Gg CH <sub>4</sub>	Gg DC	Gg CH <sub>4</sub>	in Gg	in %
<b>1985</b>	46.43	1.51	322.48	6.45	4.94	327%
<b>1985-87</b>	45.67	1.48	322.48	6.45	4.97	334%
<b>1986</b>	46.65	1.52	322.48	6.45	4.93	325%
<b>1987</b>	43.94	1.43	322.48	6.45	5.02	352%
<b>1988</b>	47.76	1.55	322.48	6.45	4.90	316%

	ORIGINAL		NEW		difference	
	Gg DC	Gg CH4	Gg DC	Gg CH4	in Gg	in %
1989	43.26	1.41	305.08	6.10	4.70	334%
1990	39.87	1.30	290.00	5.80	4.50	348%
1991	35.85	1.17	274.92	5.50	4.33	372%
1992	32.61	1.06	259.84	5.20	4.14	390%
1993	29.59	0.96	244.76	4.90	3.93	409%
1994	26.89	0.87	230.84	4.62	3.74	428%
1995	32.25	1.05	286.52	5.73	4.68	447%
1996	37.44	1.22	283.62	5.67	4.46	366%
1997	30.21	1.07	280.72	5.61	4.55	427%
1998	31.46	1.05	287.72	5.75	4.71	450%
1999	28.85	0.94	284.20	5.68	4.75	507%
2000	27.63	0.90	277.49	5.55	4.65	514%
2001	21.50	0.68	273.47	5.47	4.79	701%
2002	272.80	5.12	272.80	5.12	0.00	0%
2003	240.50	4.51	240.50	4.51	0.00	0%
2004	224.82	4.22	224.82	4.22	0.00	0%
2005	213.98	4.01	213.98	4.01	0.00	0%
2006	182.22	3.42	182.22	3.42	0.00	0%
2007	182.22	3.42	182.22	3.42	0.00	0%
2008	141.37	2.88	141.37	2.88	0.00	0%
2009	148.90	2.91	148.90	2.91	0.00	0%



## PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

### 11 KP-LULUCF

#### 11.1 General information

According to Decision 16/CMP.1, Parties to the Kyoto Protocol (KP) must submit information on land use, land-use change and forestry (LULUCF) that is supplementary to what is contained in the report under the UNFCCC. This decision sets principles to govern the treatment of LULUCF activities in Hungary; provides a common definition for terms such as “forest”, and definitions for activities under Article 3.3 and agreed activities under Article 3.4; and describes how modalities, rules and guidelines are implemented relating to the accounting of activities under Articles 3.3 and 3.4. Good practice guidance concerning the methodology for estimating GHG emissions and removals are applied as given in Chapter 4 of the Good Practice Guidance on the LULUCF sector by the IPCC (2003).

Hungary started to report LULUCF-related information in its Initial Report under Article 7, paragraph 4, of the Kyoto Protocol

([http://unfccc.int/files/national\\_reports/application/pdf/hungaryareport\\_v4fin\\_c3.pdf](http://unfccc.int/files/national_reports/application/pdf/hungaryareport_v4fin_c3.pdf))

where, among others, Hungary reported the election of an activity under Art. 3.4, i.e. 3.4 Forest Management (FM), and broadly defined both FM and “forest”.

Hungary submits this part of her NIR as supplementary information based on the above legal documents. Information on forests not contained in this chapter can be found in Chapter 7 of the NIR. We submitted our first report with supplementary information under the Kyoto Protocol in 2010. Note that we have not received the official final version of the review report of our previous submission related to the KP until the date of this submission, so it was not possible to incorporate comments or suggestions of the ERT included in that review report.

As stated above, of all the possible options for the LULUCF sector under the KP, Hungary only elected FM under Art. 3.4. Thus, this part of the NIR mainly covers issues related to the forestry sector. Information on other land use related activities (e.g. cropland management) is limited to relevant information about land use conversions.

##### 11.1.1 Definition of forest and any other criteria

As defined in our Initial Report, Hungary has chosen the following elements and single minimum values for „forest” (**Table 11.1**):

**Table 11.1.** Definition of “forest” with prescribed characteristics and the justification of the chosen value.

Characteristics	Chosen value	Justification
Single minimum land area	0.5 ha	identical with value reported to FAO earlier
Single minimum width of forest area	10 m	defined by the methodology of current forest inventory
A single minimum tree crown cover value	30%	identical with value reported to FAO earlier
A single minimum tree height value	5 meters	identical with value reported to FAO earlier

Concerning the **minimum size** of land area, it is the minimum size, by law, of forest stands. The mean size of stands in the country is around four ha. There are also patches of forests in

the country that are smaller than 0.5 ha, however, these patches are not surveyed currently. Concerning **minimum width**, the chosen value occurs quite rarely, and the width of 10m allows for only 3-4 rows of trees.

Concerning **minimum crown cover**, the vast majority of the forests are on sites that allow for closed canopy closure already in young stands, and this closure is usually kept well above 50% until final harvest and regeneration. There are some stands in the country on sites where forests would not necessarily occur under natural conditions (and thus have low crown closure), however, the proper and intensive management of even these stands ensures that they would usually have more than 50% crown closure. None of these stands would be cultivated if the management of these stands were not profitable, which requires relatively high crown closure.

The above also holds true for **minimum tree height**. It only happens on very few extreme sites that trees cannot reach a mean height of five meters at maturity.

In addition to forestry aspects, the above elected definitions match those applied in the forest inventory and monitoring: the definition was elected also in order to attain the highest possible accuracy in reporting. Moreover, the selected values are consistent with those reported to FAO and used in other international statistics.

The definition of “forest” under the KP is exactly the same as that under the UNFCCC.

Note, however, that additional information is needed to define “forest” under the KP, e.g. *when* a certain piece of land becomes “forest” due to an afforestation or reforestation activity, and which areas are accounted for under FM. These additional pieces of information are detailed in the following sections as appropriate.

### **11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol**

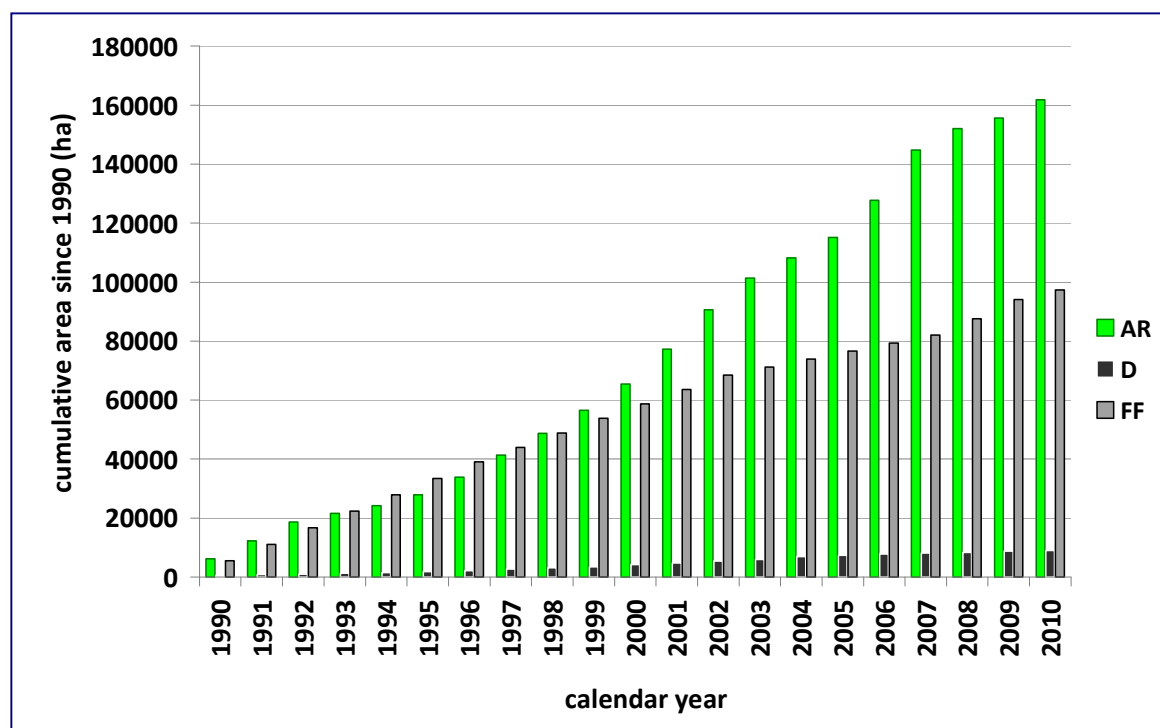
As stated both in our Initial Report, as well as above, Hungary only elected FM under Article 3, paragraph 4.

### **11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time**

Under the UNFCCC, emissions and removals from forests must be reported for “managed forests”. As reported in our NIR (Chapter 7), all forests can be regarded as “managed”. However, as discussed already in Chapter 7, some forests in each new inventory year are classified as “found forests” (FF), i.e. forests that are identified in a particular reporting year (i.e. never before) and that, in order that carbon stock change estimation is performed accurately, cannot be included in Forest Land in that year. The total area within the forestry sector under the KP can thus be divided into the following categories for each inventory year:

- AR: land under afforestation or reforestation since 1990
- D: land that has been deforested since 1990
- FM: all other forest land that was known to exist 31 December 1989 less D
- FF: found forest, which is the remaining part of the FL area in each inventory year, and which must be excluded from FM.

In the remaining parts of this section, first we define each activity below. The definitions are consistently applied throughout the period 1990-2010. The evolution of the area of the above categories except for FM is demonstrated in **Figure 11.1**. As shown below, the area of land under FM slightly decreases by D, and amounts to 1657 kha in 2010 which, as the area of D is small and rounding is applied, is about the same as in 2008 and 2009.



**Figure 11.1.** The evolution of the cumulative area of AR, D and FF between 1990-2010

However, further specific information is required concerning how these categories may overlap, and how they are separated. This information along with the method of identifying land under the various KP activities will be provided under the subsequent headings in this section. Information on FF can be found both in Chapter 7 and in section 11.2.2 below.

#### 11.1.3.1 Definition and identification of “AR since 1990”

AR in general is an activity that produces “forest”, as it is defined above, on land that was not covered by such a “forest” before. The category “AR since 1990” includes all forest that has been established since 1990, and that has not been deforested (no AR land has been deforested in Hungary so far). However, this category can only include forest that can be demonstrated to have originated due to direct human induced activity. We thus include only areas here that can be demonstrated to have been established due to direct human activity.

In Hungary, afforestations are done in three steps. The first step is to do site preparation and, after this, to plant the propagation material in the area (initial planting). The second step is a period of one to several years when the newly established stand is tended and beating-up is done if deemed necessary. Finally, the third and last step is when the afforestation is deemed “mature”. At this point, the stand is inspected, and, if it is found to have established itself and is expected to be able to survive, grow and develop to a fully mature forest, it is regarded as a “certified forest” (however, under the UNFCCC, it is only moved to the FL-FL category 20 years after the planting has taken place, see section 7). The whole process from site preparation to certification can last from one to 10-15 years, depending on species, site, weather and other factors, see **Table 11.7** below.

It is noted that we began to identify “AR since 1990” areas (altogether some 178 kha since 1990) by considering the database of the above certificates. However, we found that some of these areas have not yet entered, or could not be identified in the NFD, which contains growing stock information, and which is used for the estimation of emissions and removals. Therefore, we only included the smaller of the two sets in the “AR since 1990” category, i.e.

the one for which we have data in the NFD.

In relation to the KP, which sets a specific cut-off point (1 January 1990) in requesting countries to account for afforestations/reforestations, it is important to precisely define afforestations considering this cut-off point. In Hungary, in order to be conservative, “afforestations since 1990” are those, and only those, areas where both site preparation, as well as the planting of the propagation material started to happen after 1 January 1990. In general, site preparation and planting do occur in the same season anyway, shortly one after the other. As all areas where planting has occurred eventually become “forests”, they all enter the category “AR since 1990”.

It is also important to define the cut-off point after which an afforestation counts as an area “subject to 3.4 FM”. Indeed, due to provisions of the Forest Act, all afforestations become subjects to FM right away as they enter the AR category.

We note here that the category “AR since 1990” includes the areas of stands that were afforested, but not adjacent roads or other areas that are not covered by trees, see section 11.2.2. below.

Finally, we also note that the statistically captured forest area keeps increasing at a rate that is higher than the area of land under AR. This is due to “found forests” as explained later, however, it must be mentioned here that non-registered and illegal afforestations, as well as unregistered natural expansion of the forest are regarded as changes that do not comply with the definition of AR, therefore, these areas are excluded from the AR category.

#### **11.1.3.2 Definition and identification of “D since 1990”**

D areas are those that have been clearcut and removed from areas under forest management in order that the area can be used for non-forestry purposes (i.e., for other land use).

It follows from the above that an area enters the D category right away, i.e. in the year, of the clearcut which is made in order that the area can be used for non-forestry purposes.

In Hungary, deforestations have not been done frequently since 1990 nor were they done before that. The location of D areas is known since 2008, however, it was of no importance for the forest inventory earlier, and the exact location of most deforestations prior to 1 January 2008 are known. However, all deforestations have to be certified, so we set up a system to identify at least the total area of deforestations from all available information.

The total area of deforestations was established based on statistical data collection back to 1990 using the certificates of the deforestations. However, it was suspected that these certificates are fully available only since 2003. Therefore, another, sample-based study was made that indeed showed that the total area of the deforestations before 2003 that could be retrieved from the National Forestry Database, which contains data of forest stands only, was higher than the one that could be developed from the hard copy files of the certificates. This means that in fact some certificates, thus, some deforestation areas could not be identified by only using these certificates. Therefore, the area established by the certificates before 2003 was multiplied by a factor of 1.18, which was established in the above study and was deemed representative for the whole country, to estimate the area of the total deforestations before 2003. We could thus establish a full time series data of deforestations since 1990 (**Table 7.6** and **Figure 11.1**).

It is noted here that, just like with AR, D areas only include the area of stands, which in the case of deforestation have been deforested, and exclude areas outside of the stands, like roads, see section 11.2.2 below.

The demonstration that regenerated areas under FM are not accounted for as D can be found in section 11.4.2.

### 11.1.3.3 Definition and identification of “FM since 1990”

The definition of “forest management” in Hungary is well described in the Forest Act. The relevant forest act that was mainly in effect for the period of 1990-2008 was passed by Parliament in 1996 (Act LIV of 1996 on Forests and the Protection of Forests, see at [http://www.mgszh.gov.hu/data/cms/132/407/Act\\_LIV\\_of\\_1996\\_eng.doc](http://www.mgszh.gov.hu/data/cms/132/407/Act_LIV_of_1996_eng.doc)). Article 7 of this Act stated that “For the purposes of this Act, forest management shall be qualified as the entire range of activities aimed at maintaining, guarding and protecting forests, ensuring their public function, increasing forest assets, and exercising the forest usufructs in accordance with the provisions of Article 2.” The relevant section of Article 2, in turn, reads: “Forests should be used and exploited in such a manner and at such a rate, which allows the prospects of management to endure also for future generations (hereinafter referred to as: sustainable forestry), so that the forests preserve their biological diversity, naturalness, fertility, ability to regenerate, viability, furthermore, that they satisfy the protective and economic needs in harmony with the requirements of society, and fill their role serving the purposes of nature conservation and environmental protection, health and welfare, tourism, research and education.” Note that a new forest act was passed in 2009 (Act XXXVII of 2009 on Forests, Protection of Forests and Forest Management), which further reinforced provisions to protect forests, avoid deforestations, and initiated a transition to close-to-nature forestry at an increased rate. (The text of the Act, currently in Hungarian, can be found at [http://net.jogtar.hu/jr/gen/hjegy\\_doc.cgi?docid=A0900037.TV.](http://net.jogtar.hu/jr/gen/hjegy_doc.cgi?docid=A0900037.TV.))

“Forest management” in general thus includes all kinds of activities in the forest from protecting forests through their economic utilization (of all kinds) to making use of a wide variety of social and ecological functions and services of the forests. All these activities often require rather intensive management of all forests, although this intensity is quite different in the various stands depending on site, species, and the local objective of managing the stand. Managing forests involves preparing forest management plans, afforesting, regenerating, intensive thinning, harvesting, forest protection, maintenance of roads and road building, inspecting of forestry operations and others. The intensity of management is characterized by the length of the operational cycle of returning to each forest compartment (of about four ha in average as mentioned above), which varies from about a few weeks (in afforested or regenerated areas where tending is necessary) to a year (in young poplar stands for tending) to five years (between precommercial thinnings in young stands of fast growing species) to maximum 15-20 years (between thinnings in older stands of slow growing species). Forest management planning covers all forests, and forest management plans are made for 10(-12) years. That all forests (in the sense of the above “forest” definition) are managed in one way or another in Hungary is partly an economic and practical necessity because the country uses more wood a year than what it produces, and because the density of the population, which requires all kinds of products and services from the forests, is quite high according to official statistics (108 capita km<sup>-2</sup>, KSH 2009).

We also note that there are practically no remnants of virgin forests, old growth forests or other primary forests in the country. There are some 70 so called forest reserves in the country, whose total area amounts to some 12 kha. Forest operations in these reserves are limited to a so called protection zone (altogether about 8 kha), which makes up most of the area of these reserves, and which surrounds the so called core zone where no traditional operation is conducted in (altogether about 4 kha). However, there is usually some activity

even within these core areas such as protection by fencing, wildlife management, forest protection, research and education, and tourism. All protected forests are also included in the so called “Natura 2000” protection network that involves various protection measures.

The above means that Hungary applies a *broad definition* of “Forest Management under Art. 3.4”.

We also note that as activities include preparing forest management plans for the majority of stands, surveying and inspecting stands regularly, and conducting various types of thinnings rather intensively etc., as well as that one or several of these activities do occur in each stand each year, all forests in Hungary are regarded as “*managed since 1990*”.

Land under the “FM since 1990” activity is identified by establishing FM in 31 December 1989 (which equaled the total FL at that point) and then subtracting D areas in subsequent years. It also means that no land has been added to FM since 1989, thus, FF (that are also discussed in Chapter 7.3) are also excluded from FM.

It is finally also noted here that for area of FM, just like for AR and D, we report the total area of stands for FM, and exclude the area of associated roads etc., see section 11.2.2. below.

#### **11.1.3.4 Separating AR from FM**

As stated above, one or more years after the beginning of an afforestation, which depends on species and site fertility, all AR lands become “forest” from the viewpoint of the definition of “forest” under the KP. From a domestic administrative point of view, when an AR land becomes a “forest” under the Hungarian regulations, it right away becomes an area subject to FM. Thus, since the category “AR since 1990” includes all areas that have been afforested since 1990, these areas could also be regarded as 3.4 FM.

Double counting is avoided, and full consistency with the report under the UNFCCC is achieved, by not establishing FM from an “independent” data source, rather, by making sure that FM is equal to the difference of all forests (“FL” in the report under the UNFCCC) minus the total of the “AR since 1990” (see below) minus “D since 1990” minus “FF” (see below). In this way, AR since 1990 that would otherwise classify as FM is automatically excluded from FM.

#### **11.1.3.5 Separating D from FM**

This issue is covered under section 11.4.2.

#### **11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified**

As Hungary only elected FM under Article 3.4, no precedence or hierarchy issues arise.



## 11.2 Land-related information

### 11.2.1 *Spatial assessment unit used for determining the area of the units of land under Article 3.3*

The spatial assessment unit in Hungary is 1 ha. This is ensured by the forest inventory that includes information of stands as small as 0.5 ha, i.e. areas that are smaller than 1.0 ha. Individual stands that are larger than 0.5 ha are also mapped at a spatial assessment unit of around 0.5 ha.

### 11.2.2 *Methodology used to develop the land transition matrix*

Land transition matrix is developed the following way:

- Areas under annual AR activities are identified on a per stand basis each year, and the area of these stands are summed up.
- AR stands that are harvested and that are not harvested are also identified on a per stand basis as it is recorded in the National Forestry Database (NFD) if an AR stand is harvested or not.
- Areas under D activity are identified since 1 Jan 2008 on a per stand basis each year, and the area of these stands are summed up.
- The total forest area at the end of each year (since 1990) is identified on the basis of the NFD that includes appropriate records for each known stand in the country.
- Land under FM was identified at 31 December 1989. FM area has subsequently been reduced by the area of the deforested stands, and has not increased in any inventory year since 1990.
- Both before and in years 2008, 2009 and 2010, all changes in the forest area were also identified that were not due to AR or D activities (i.e., FF).  
The above procedure is done for all geographical locations regions in the country, and is also summed up at the country level.

The above procedure ensures the consistency of land under all KP activities, as well as FL under the UNFCCC.

The land transition matrix is to be reported beginning with the inventory year of 2008. However, as activities under the KP are defined “since 1990”, land use changes must be tracked back to 1990. Also, land allocation has evolved since 1990, and changes of land use occurred that cannot readily be classified under any KP activity. We therefore identified all changes in the land use statistics and classified them so that, eventually, all land can be accounted for in the respective categories since 1990.

In order to demonstrate that the land use and land use change information as reported under the UNFCCC is consistent with information under the various activities under the KP, below is a summary of the method of establishing the area of FM with the relevant data at the country level.

It must be noted here that, as discussed in Chapter 7.3, we report the total “Forest land” area in the CRF table under the UNFCCC, which is more than the total areas of all stands. The reason for reporting this area is that it is only possible to account for all land area of the country in the CRF tables under the UNFCCC if this area is to be consistently reported together with the area of all other land uses so that the total of all these areas add up to the total land area of the country. However, for KP reporting purposes, we can only use and report the total area of stands, or sub-compartments, which is included in the above “forest land” but excludes areas outside of the stands such as roads. However, the area of stands includes areas *within* the stands that are occasionally not covered by trees. We use this area



The time series data of all the above forest area categories, along with that of the area type that is strictly covered by trees (“calculated area covered by trees”) is reported in **Table 7.5** of the NIR.

Diagram illustrating the evolution of the water table (FL) over the period 1990-2010. The diagram shows a cross-section of the water table profile, with dimensions indicating the water table level (FL) and the distance from the water table to the ground surface (D).

Key dimensions and labels:

- Known FL 1666
- Unknown FL
- D 9
- FM 1657
- FF 97
- AR 168
- FL 1922

The diagram shows the water table profile at two specific dates: 31 Dec 1989 and 31 Dec 2010. The water table level (FL) is shown to have decreased over time, with the distance from the water table to the ground surface (D) increasing.

**Figure 11.2.** Graphical demonstration of changes in the area (kha) of the various activities under Articles 3.3 and 3.4 of the KP since 1990. The area denoted by the dashed lines is equal to the area over time identified by the NFD in each inventory year except for the AR area, i.e. the area of FM + that part of the FF that was identified up to the inventory year. Data under various activities are area of sub-compartments (they are slightly different from respective numbers as reported elsewhere due to rounding-off). See text for other details

Based on the definitions and the graph as outlined above, the areas of the sub-compartments under the Article 3.3 and 3.4 activities as of 31 December 2010 are derived the following way (only rounded numbers are used; for precise numbers, and for data by geographical locations, see the KP CRF table):

FL:

**Forest Land 31 December 1989** = Known Forest Land 31 December 1989 = **1,665.6** kha

AR:

AR land 31 December 2007, since 1990 = **151.4** kha

New AR land in 2008 = **7.2** kha

New AR land in 2009 = **3.5** kha

New AR land in 2010 = **6.3** kha

**Total AR land 31 December 2010** =  $151.4 + 7.2 + 3.5 + 6.3 = 168.4$  kha

D:

D land 31 December 2007, since 1990 = **8.1** kha

D land in 2008 = **0.3** kha

D land in 2009 = **0.5** kha

D land in 2010 = **0.2** kha

Total D land 31 December 2010 =  $8.1 + 0.3 + 0.5 + 0.2 = 9.1$  kha

**FM:**

FM land 31 December 1989 = **1665.6** kha

FM land 31 December 2008 = FM land 31 December 1989 - Total D land 31 December 2008  
=  $1665.6 - 8.4 = 1657.2$  kha

FM land 31 December 2009 = FM land 31 December 1989 - Total D land 31 December 2009  
=  $1665.6 - 8.9 = 1656.7$  kha

**FM land 31 December 2010** = FM land 31 December 1989 - Total D land 31 December 2010  
=  $1665.6 - 9.1 = 1656.5$  kha

**Total changes accountable under the KP:**

Total of above changes until 2007 = AR 2007 – D 2007 =  $151.4 - 8.1 = 143.3$  kha

Total of above changes until 2008 = AR 2008 – D 2008 =  $158.6 - 8.4 = 150.2$  kha

Total of above changes until 2009 = AR 2009 – D 2009 =  $162.1 - 8.9 = 153.2$  kha

Total of above changes until 2010 = AR 2010 – D 2010 =  $168.4 - 9.1 = 159.3$  kha

**FF:**

Total FF between 1990-2007: **82.0** kha

addition in 2008: **5.6** kha

addition in 2009: **6.5** kha

addition in 2010: **3.1** kha

Total FF 1990-2008 =  $82.0 + 5.6 = 87.6$  kha

Total FF 1990-2009 =  $82.0 + 5.6 + 6.5 = 94.1$  kha

**Total FF 1990-2010** =  $82.0 + 5.6 + 6.5 + 3.1 = 97.2$  kha

**Checking:**

Forest Land 31 December 2010 = Forest Land 31 December 1989 + Total accountable changes under the KP + Found forests = 1,665.6 + 159.3 + 97.2 = **1,922.1** kha

Forest Land 31 December 2010 = FM + AR + FF = 1,656.5 + 168.4 + 97.2 = **1,922.1** kha

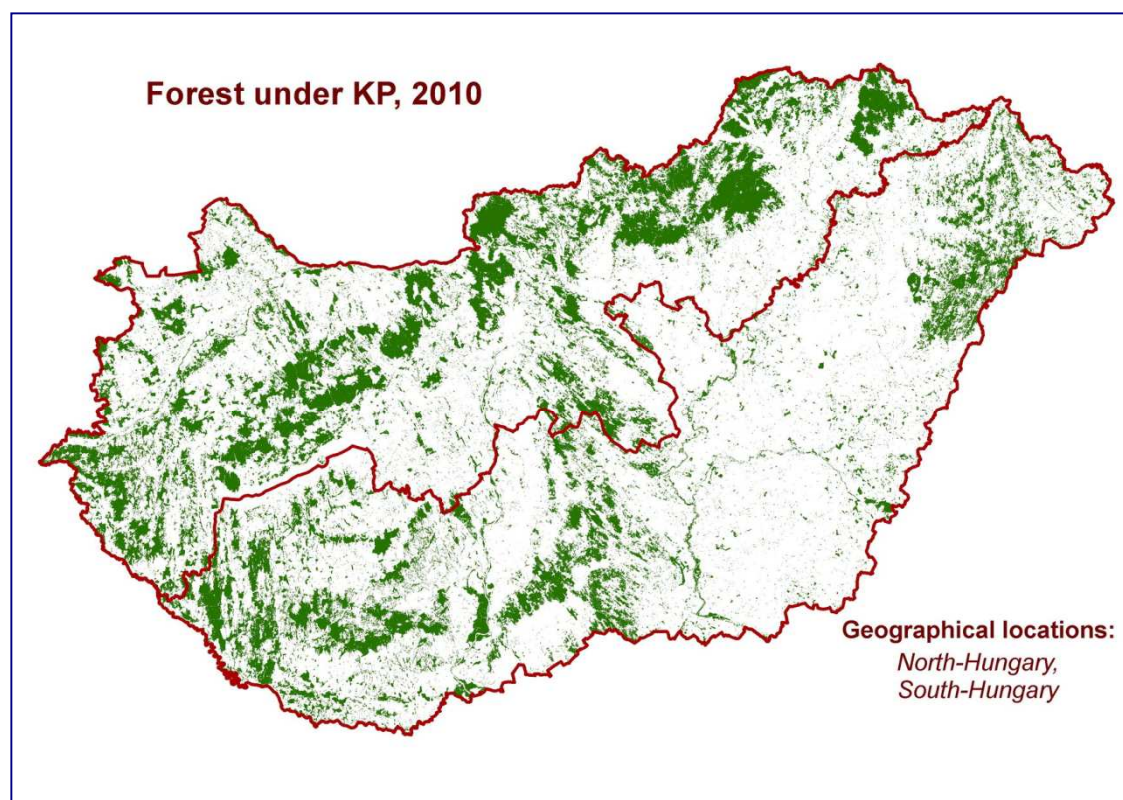
The above calculation demonstrates that (1) all land is accounted for; (2) double counting is avoided; (3) all areas that are not in subcompartments, but are included in the “forestry area” (i.e., 2,046.4 - 1,922.1 = 124.3 kha in 2010, see **Table 7.5** of the NIR) are accounted for under “Other” of the KP CRF table (Table NIR 2. LAND TRANSITION MATRIX).

### **11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations**

Hungary applies **Reporting Method 1** of the IPCC GPG for LULUCF (2003). This means that we identify regions for which we developed total areas under the various KP activities.

**Two geographical locations** are separated, and they are called North-Hungary and South Hungary (see **Figure 11.3** below). These are geographical locations that are separated along the borders of municipalities (which in turn follow partly other administrative, partly natural borders), and that were found appropriate for the purposes of this reporting. The identification codes used in the CRF tables are the following: North-Hungary, 1; South-Hungary, 2. „North” consist of the North Hungarian Mountains, the agglomeration of Budapest, the Transdanubian Mountains (north to Lake Balaton) and the Little Hungarian Plain. The Great Hungarian Plains and the Transdanubian Hills (south to the Lake Balaton) belongs to „South”.

Both area and emission and removal data for the above geographical locations are derived from stand, or subcompartment, level data. The identification system of subcompartments is made up of three elements which are registered for every subcompartment. These elements are: the municipality (village, or town), the compartment (a larger piece of forest, e.g. a hillside or a valley) and subcompartment (which is part of a compartment). The subcompartment is the basic unit of forest management, its mean size being approximately 4-5 ha. The number of municipalities was 3166 in 1990 and 3187 in 2010, so the borders of the municipalities are considerably stable over time. (The borders of municipalities declared and mapped by the Institute of Geodesy, Cartography and Remote Sensing, FÖMI, Hungary.) Since every subcompartment exactly belongs to a municipality, and municipalities are unambiguously mapped, the geographical locations can be developed.



**Figure 11.3.** Map of Hungary with forests (green patches) and the border of the two geographical locations.

## 11.3 Activity-specific information

### 11.3.1 Methods for carbon stock change and GHG emission and removal estimates

#### 11.3.1.1 Description of the methodologies and the underlying assumptions used Definition of pools as applied in Hungary

The IPCC GPG for LULUCF defines carbon pools in a generic manner. In Hungary, pools are defined in a bit different, and more specific way to match them to available data in order that the estimation is as accurate as possible and practicable. These definitions are the same as in section 7 of the NIR, i.e. those under the UNFCCC. In the estimations, we apply the following definitions:

Above-ground biomass (AB): all biomass of living trees, including bark, branches, twigs and leaves, that can be found above the height of potential cutting of the stem by chainsaw. This height is usually a few cm above ground; only 1-2 cm for small trees (e.g. at thinning age), and 5-10 cm for bigger trees, and can be 10-20 cm for trees of the age of final harvest.

Below-ground biomass (BB): all living parts of the living trees below that above-mentioned potential cutting height. These parts thus include the stump, coarse roots and fine roots.

Litter (LI): all dead plant mass, whether above-ground or below-ground, that is smaller than around 10 cm in diameter (in case of branches and roots). Note that as no quantitative measurement of the change of the litter has been attempted so far, this 10 cm in diameter is just a theoretical value of currently no practical importance.

Deadwood (DW): all dead plant mass that is not litter (i.e., above the 10 cm threshold for

standing and lying dead trees, and above the threshold of 20 cm for stumps).

Soil (SO): includes the organic carbon in the topsoil down to a depth of 30 cm. Inorganic carbon, as well as organic carbon in the below-ground deadwood and litter pools are excluded, but organic carbon in the topsoil layer is included.

### **General methodological notes**

The emissions and removals on land under AR and D are different from those under the various categories under the UNFCCC, i.e., “Land converted to forest land” and “Forest land converted to other land”. Therefore, these emissions and removals must be estimated using specific procedures. All procedures are accurate as far as practicable.

The procedures are pool-dependent in the case of Hungary. As it is detailed below, Hungary directly estimates emissions and removals in the above-ground and below-ground biomass pools for AR, D and FM, and emissions from soils and DOM for D, however, it only demonstrates that the deadwood, litter, and soil pools are not a source for the aggregated forest area (i.e., AR and FM). Thus, Hungary's report is complete as it covers all carbon pools, and also complete as it covers each activity under the KP.

With regard to the processes that may bring about changes in the carbon pools, the report can also be considered complete. The carbon stock changes in the biomass pool are estimated using the stock change method (in a similar fashion than for categories under the UNFCCC), which automatically ensures that all processes, i.e. all changes due to gains, i.e. growth, and all changes due to losses, i.e., harvest, natural disturbances like fires etc., are taken into account. With respect to the pools where demonstration is applied, all major processes are also considered (see below).

For the biomass pools, the estimation of emissions and removals in lands under the AR and D activities are directly estimated from the carbon stocks of consecutive calendar years (for AR), i.e. from carbon stocks as of 31 December 2007-2010, and of the inventory year of 2008-2010 (for D).

These carbon stocks are calculated from stand level volume stocks of each stand under the various activities using the equation in section 7.3.1 of the NIR (which is basically an adapted version of the relevant equations in the IPCC, 2003, GPG). This implies the assumption that there is no deadwood or litter, and there is biomass only in case of former vineyards and orchards in the afforested land before the afforestation. This is justified as most afforested lands are abandoned croplands and abandoned grasslands where it takes substantial time for a natural vegetation to establish perennial vegetation of substantial biomass, which can rarely happen in Hungary. Removals due to this establishment are not accounted in Hungary, either.

To estimate growing stock in the afforested areas, empirical yield tables and local (ground-based) field measurements are used for the appropriate combinations of species and site conditions as a component of the national forest inventory. Since forest of AR category identified and mapped on subcompartment (stand) level, the surveys of the NFD can be applicable, and there is no need the model used for estimating L-FL removals (see chapter 7.3.2).

Other parameters of the equation are also as detailed in section 7.3.1. However, we highlight here that, in lack of country-specific measurements, the same root-to-shoot value of 0.25 is assumed for stands of land under AR as for all other forests. This can be regarded as rather conservative because young trees usually have higher root-to-shoot ratios than mature trees. This assumption thus leads to an underestimation of removals on AR land.

It must also be noted here that the forest inventory is designed to provide information on the actual *situation* (i.e., stocks) of stands *in each year*. However, the borders of the stands often change due to reasons of ownership of changes of professional standards, and it is not possible to keep track of most of these changes at the stand level. This means that the carbon stock changes cannot always be estimated bottom-up from the stand level, rather, they can only be calculated at an aggregate level of categories of AR, D, FM, and FL-FL and L-FL, and for the level of geographical locations and all forests (i.e., FL). .

The emissions and removals for lands under FM are indirectly estimated. This is done in order that the estimates under the UNFCCC and under the KP are consistent, that carbon stock changes are neither underestimated nor overestimated, and that double counting is avoided. With this approach, total net removals (NR, i.e., gains) for FM are calculated using NR of FL under the UNFCCC, NR on land under AR and NE (net emissions) on deforested land, while excluding FF, according to the following equation:

$$\begin{aligned} &\text{Total NR of forests under FM in 2010} = \\ &+ \text{Total NR of FL-FL in 2010} \\ &+ \text{Total NR of L-FL (gains) in 2010} \\ &- \text{NR of AR (gains) in 2010} \\ &\quad - \text{NR of FF 1990-2010 in 2010} \end{aligned}$$

**At the country level, in Gg CO<sub>2</sub>:**

$$\text{Total NR of forests under FM} = -1,994 + (-1157) - (-1,294) - (-154) = -1,703 \text{ (slightly different from the numbers in the CRF table, only due to rounding-off).}$$

In this calculation we take the same area specific carbon stock changes for FF that can be calculated for the entire forest area, and which is 1.64 tCO<sub>2</sub>/ha for 2010. That the same value can be used for both the entire area and the FF is justified by the similar distribution of the FF and the entire forest land by species, age and site.

For biomass, the methods of the forest inventory are the same that are described in the NIR under the UNFCCC. These methods are regarded as very detailed, and being capable of even capturing all emissions from deforestations.

For the non-biomass pools, different approaches are taken for D, and for the other activities.

On D lands, we assume that, in the year of the deforestation, all above-ground and below-ground biomass, as well as DW and LI is completely removed from the area, i.e. carbon in these pools are emitted in the year of the deforestation, and, emissions from total carbon stock changes from forest to non-forest in soils are also accounted for in the year of the deforestation. The procedure and the estimated values can be found in section 7.3.3 and in **Table 7.11**, respectively.

Finally, it is assumed that neither biomass, nor deadwood or litter is produced any more in D areas after the conversion, thus, no removals are accounted for.

For the non-biomass pools on AR and FM land, the option of paragraph 21 of decision 16/CPM.1. is selected, and it is demonstrated (see below) that these pools are not a source, thus, no accounting is made for these pools.



### 11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

For FM and AR, Hungary does not explicitly quantify emissions and removals for three forest carbon pools, i.e. soil, deadwood and litter, but demonstrates that these pools are not a source. To demonstrate that soils are not a source, a conservative approach is taken that is based on the IPCC 2006GL methodology, and international and country-specific data. The demonstration for DW and LI is based on expert judgment which is a practicable method in our situation (see below).

#### Demonstration for FM and AR that the soil carbon pool is not a source

This demonstration is necessary because, until this point, there has not been any soil carbon monitoring program in Hungary. However, we have used all available country-specific data and information for the below demonstration, thus, the demonstration includes Tier 2 elements.

We note here that a major research project was completed since the 2011 submission, so much new information is available to support the demonstration. The aim of this research, conducted between 2009-2011, was to develop more country-specific data for the demonstration. Because of this, some data of the demonstration has been changed since last year, and more information is provided in the demonstration. However, we continue to apply the conservativeness approach, i.e. we always apply the information from various options, when there is any, that leads to higher emission estimates and lower removal estimates. Overall, the new data suggests that the demonstration can be done with a much higher certainty than before.

Also to be noted is that, because we have now more evidence for the demonstration, and in order to comply with relevant requests from ERT of the latest inventory review, we present the demonstration separately for AR and FM land.

In lack of country-wide direct measurements, information and data can best be used if the country is stratified (from a statistical point of view) in terms of *processes* that may bring about carbon stock changes. These processes are both natural and direct human induced ones. Concerning these latter ones, they predominantly occur when forests are disturbed by harvesting or soil preparation. Therefore, forest land will first be stratified according to the *main types of forest operations* for which land area data is available. Then, a rate of emissions or removals will be assigned to the various strata. Finally, it will be shown that even if large emissions are assumed for strata of net emissions and small removals are assumed for strata of net removals, the overall carbon balance of the soils of the Hungarian forests is positive, i.e. removals are greater than emissions.

We note here that an earlier version of the procedure was successfully demonstrated to experts in an international expert meeting (Somogyi, 2006).

We also emphasize that the strata that are defined and separated in this demonstration into two groups are based on relevant KP activities and available country-specific data. One group of strata consists of two strata that include areas where afforestations and reforestations occurred since 1990 on cropland and grassland, respectively, whereas the other group consists of three strata of the remaining forests (i.e. FM land) where various other types of forestry operations take place or where no operations take place at all in the inventory year. Thus, the system of strata in the demonstration overlap with the activities under the KP. The demonstration is separately presented for the two groups of strata, i.e. for the two major types of activity that are relevant for Hungary.

Below we first provide details on the strata that we identified together with methodologies of how carbon stock changes are estimated for them, then we provide a summary of total carbon stock changes by stratum and for the entire forest land under the KP.



### 1. Afforestations and reforestations since 1990

Afforestations and reforestations are in general areas where, depending on local conditions, soil preparation may take place, and of course planting or seeding always take place. These procedures may lead to carbon emissions. Also, changing land use can sometimes lead to loss of carbon, e.g. in the case of converting grassland to forest land. On the other hand, removals always occur in these areas due to the growth of the new vegetation. On balance, the areas may be net sinks or sources. Whether they are sinks or sources also depends on the time that has elapsed since the beginning of the afforestation.

In order to estimate the net carbon stock changes due to afforestations, two country-specific equations can be applied that specifically provide estimates of carbon stocks over time after the afforestation. The equations depend on whether the land that was afforested had earlier been *cropland* or *grassland*.

The total area of all afforested and reforested land since 1990, as reported above, is 168.4 kha. The carbon balance of this area at any given time after 1990 depends on the relative amount of land that was cropland and that was grassland prior to the afforestation, and the area specific rate of emissions and removals.

Concerning the ratio of the area of these two types of land, there are no reliable estimates for historic times, however, sample-based estimates were made for selected years to cover the 1990-2010 period for which we could identify land use prior to afforestations. The data shows a high share of cropland as a predominant land use before afforestations with a mean value of 81%, which corresponds to field experience and consensus of experts in the field. Concerning the area specific emissions and removals, as well as total emission and removal estimates, detailed information is provided below by strata.

#### **Afforested and reforested land since 1990 that was converted from cropland**

According to local case studies that were carried out earlier (Horváth, 2006, Somogyi, 2005) and last year (Somogyi et al. 2011), carbon is hardly ever lost from soils when cropland is converted to forest. From a theoretical point of view this is because cropland soils already contain low amounts of carbon (much lower than soils under forest vegetation), and even if some small carbon is lost it is quickly offset by the increase of soil carbon due to the fast growth of young trees.

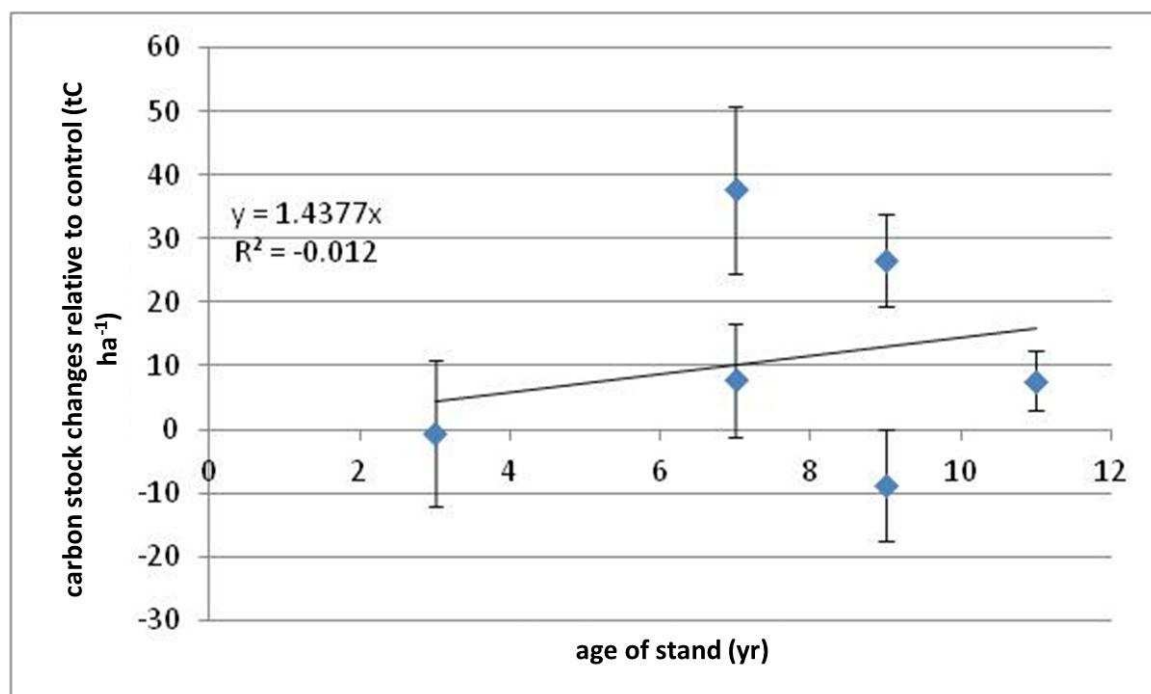
This stratum will therefore be assumed to have an overall zero or positive carbon balance, and the amount of carbon that grows over time will be assumed to take place based on a country-specific estimate. According to the equation for cropland by Horváth (2006), earlier used as the equation for cropland, carbon stock changes over time,  $t$ , after the afforestation on cropland are:

$$\Delta C_t = 43.5 \cdot (1 - e^{-0.016 \cdot t})$$

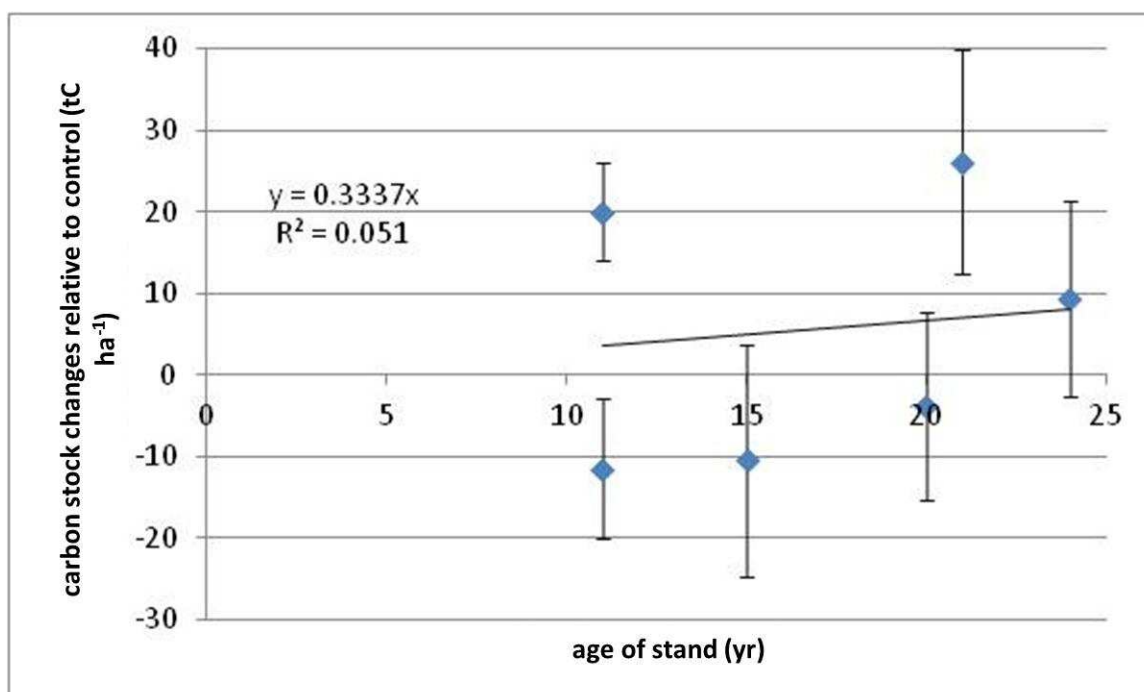
This equation is for the top 60 cm layer, however, estimates must be done for the top 30 cm only. It is well known that the majority of soil organic carbon can be found in the topsoil layer, and according to Table 4 of Hiederer (2009), the share of the SOC of the top 30 layer of all SOC in the top 100 cm of sampled forest soils (based on a fairly large sample) is, on average, 5.1/6.6, i.e. 77%. Thus, we reduced the value by the above equation by 0.33.

In order to validate the above estimate, and to reduce uncertainties, Somogyi et al. (2011) re-assessed this using a paired-plot series of cases studies. One was done in fast-growing Black locust (*Robinia pseudoacacia*) stands, and another one in slow-growing sessile oak (*Quercus petraea*) afforestations. Both species well represent typical fast and slow growing

species, and are basic components of afforestations in the past several decades. For each species, carbon stock changes were measured in the uppermost 30 cm layer relative to a control area in six case studies. The measured carbon stock changes, together with resulting fitted linear equation, which was forced to go through the origo, can be seen in **Figure 11.4** and **Figure 11.5**.



**Figure 11.4.** Carbon stock changes relative to a control area in six Black locust (*Robinia pseudoacacia*) afforestation, and the linear equation fitted to the data, and forced through the origo. (Somogyi et al., 2011)



**Figure 11.5.** Carbon stock changes relative to a control area in six sessile oak (*Quercus petraea*) afforestation, and the linear equation fitted to the data, and forced through the origo. (Somogyi et al., 2011)

As shown in the above figures, carbon stock changes over age are estimated to be  $1.4377x \text{ tCha}^{-1}$  for Black locust and  $0.3337x \text{ tCha}^{-1}$  for sessile oak, where  $x$  is for the age of the stand. Although a weighted average could be used, for the sake of conservativeness, we used the smaller of the above rates, and also took the smaller removal estimate of Somogyi et al. (2011) using this smaller rate and Horvath (2006), which proved to be the estimate (44.6) using the Somogyi et al. (2011) rate. However, this estimate is much smaller, and thus more conservative, than the one (120.8 ktC) obtained by applying the average of the rates estimated by Somogyi et al. (2011) that could be regarded as more accurate.

The choice for the smallest possible removals is also to the fact that, as it is evident from the above two graphs, the uncertainty of the rate of the stock change over the age of the stand is still very uncertain. However, Somogyi (2005), Horvath (2006) and Somogyi et al. (2011) all found only evidence of carbon stock increase, which justifies the above procedure that, by applying the most conservative estimates, the resulting estimate is regarded as sufficiently robust.

The area of this stratum is calculated as the total area of afforestations times the factor of 81% as reported above.

The result of the estimation process is that the net removals, in 2010, of AR land since 1990 that was converted from cropland are 44.6 ktC (see also Table 11.3 below).

#### **Afforested and reforested land since 1990 that was converted from grassland**

As opposed to the above case, converting grassland to forest is associated with a much more substantial disturbance as far as carbon emissions are concerned. This is mainly due to the fact that soils under grassland usually contain much more carbon than forests, thus, losses from the soil due to soil preparation, which may also be more intensive than on croplands, cannot be easily offset by the growth of forest vegetation. Indeed, a local study demonstrated that soil carbon is being lost for decades after conversion (Horváth, 2006).

This stratum will therefore be assumed to have an overall emission for decades, and the change of carbon over time will be assumed to take place according to the equation for grassland by Horváth (2006). Again, the original equation for grassland is rearranged to directly estimate carbon stock changes over time,  $t$ , after the afforestation:

$$\Delta C_t = 32.9 \cdot (1 - e^{-0.015 \cdot t}) - 29.0 \cdot (1 - e^{-0.046 \cdot t})$$

The area of this stratum is calculated as the total area of afforestations times the factor of 19%.

The result of the estimation process for this stratum is that the annual net emissions, in 2010, of AR land since 1990 that was converted from grassland are 3.2 ktC (see also Table 11.3 below).

By adding up the estimates for the above two strata for AR land for 2010, we get a removals of 41.3 ktC, thus, it is demonstrated that AR land in Hungary is not a source. For 2008 and 2009, the net removals are 39.4 and 40.3 ktC, respectively. This means that the removals of AR land have been increasing in the last few years.

## 2. Land under FM since 1990

The following strata are all parts of FM since 1990 that exclude those parts of forest land that were afforested or reforested since 1990 and that are classified as FF. These strata are defined by the forest operations that can be regarded as the most important from the point of view of emissions and removals.

### **Land under FM since 1990 where final cutting and artificial regeneration following professional standards occur**

Artificial regeneration here means that a stand is replaced by a new one by applying operations that closely resemble those of conversions. These operations may include disturbances associated with final cutting and skidding of timber, soil preparation, erosion (on steep slopes), and planting or seeding. The amount of loss may depend on tree species, site and the technologies applied.

Currently, no country-specific data exists as to the extent of possible emissions associated with such regenerations. One way to estimate these emissions is to assume that they are the same as on land that is fully converted to cropland. This is obviously a huge overestimation as only a fraction of the carbon is lost when there is no conversion and the land is only prepared for forest regeneration once, as opposed to consecutive and regular disturbance of the soil under cropland management. According to IPCC default factors (Table 7.21 of the NIR), if a forest land is converted to a full-till cropland without additional input of organic carbon (when forests are regenerated, no additional organic carbon input is applied), it loses some 18% of the original (i.e., reference) carbon stock.

With respect to the reference carbon stock, we assume the mean value (**Table 11.2**) that results from classification of the area by climate type and soil type, and from applying IPCC default soil carbon stock values (IPCC, 2006, see section 7.3 for details).

**Table 11.2.** *Distribution and carbon stock of forest soils in Hungary by climate and soil types (for details, see section 7.3).*

	WD HAC	CD HAC	WD sandy	CD sandy	Total
Distribution by percent	35.71%	53.59%	0.86%	9.85%	100.00%
SOC <sub>ref</sub> (tC/ha)	38	50	19	34	<b>43.87</b>

The overall loss is equivalent to  $43.9 \times 0.18 = 7.9 \text{ tCha}^{-1}$ . Until 2011, we used a smaller, but still very high value of  $6 \text{ tCha}^{-1}$  for the specific carbon loss for this stratum. It was assumed that all emissions due to disturbing soils take place in the year of the start of the regeneration, i.e. the above specific value is applied to the total area of the harvested forests in the inventory year.

Beginning this reporting year, we use a revised specific carbon loss for this stratum. This revision is based on the recent study (Somogyi et al. 2011) that was already mentioned above. In this study, several case studies were conducted to see the potential area specific emissions. To model these emissions, the carbon stocks of paired stands before and after regeneration (1-15 years of age) were compared, and differences were regarded as carbon stock changes. In stands of slow growing species, sessile oak was used again Figure 11.6, whereas intensively growing poplars were used to represent fast growing species Figure 11.7.

As the graphs show, there are indeed areas where carbon stocks decrease after afforestation. The changes vary between 1 and  $2.8 \text{ tCha}^{-1}$ . However, carbon stocks actually

seem to have increased after the regeneration, and the measured increase amounts to as much as  $22 \text{ tCha}^{-1}$  in the case of a sessile oak case study.

There are, however, several other factors to consider. One is that both the variation among case studies, and that of the mean values in each case study are very high. (Ten places were measured in each case study to estimate variance, and five pairs were measured for each species.) As a result, there are only three cases out of the ten shown where carbon stock changes can be regarded as significantly different from zero, however, all are positive values. The actual rate seems to depend on both species and site.

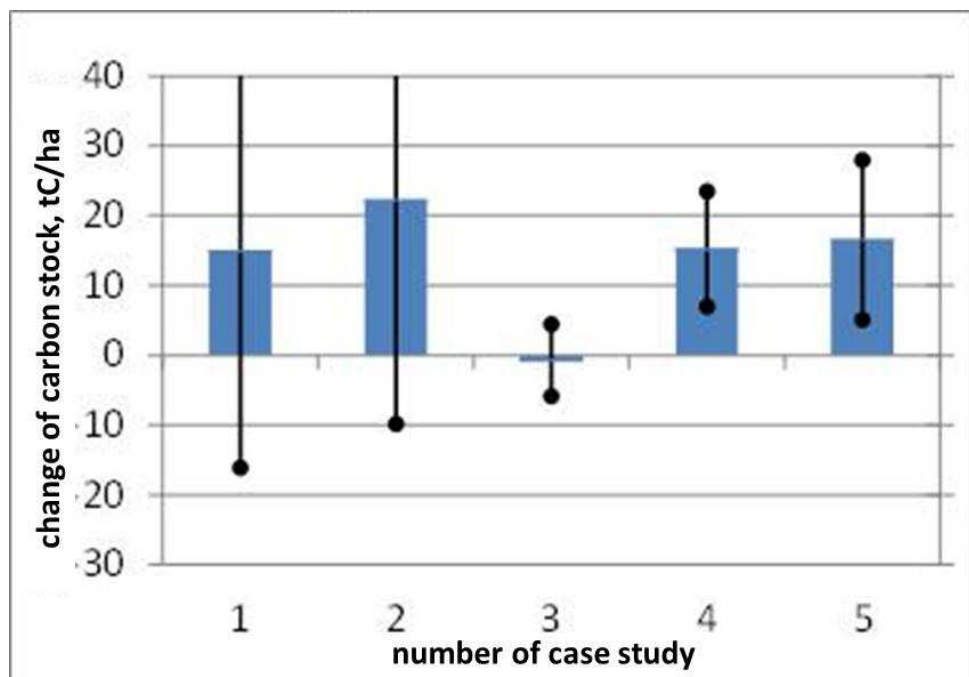
Overall, increased carbon stocks were estimated instead of the previously assumed carbon stock losses. However, this is considered valid as a result of process analysis. Based on this analysis (see Somogyi et al. 2011 for details), it is believed that this increase is due to the transfer of carbon from the dead roots of trees of the mature stand, which were harvested before the regeneration, to the soil pool. In a mature stand, it is not uncommon to have  $320 \text{ m}^3$  of aboveground wood volume (this value was only chosen for the sake of demonstration). If basic wood density is  $0.5 \text{ tm}^{-3}$  (a good approximation of national average), then aboveground biomass is  $160 \text{ tha}^{-1}$ , which translates to  $80 \text{ tCha}^{-1}$ . After applying a root-to-shoot ratio of 0.25, we get a carbon stock of 20 tC in the trees of the mature trees. Because the root-to-shoot ratio is a conservative one, this estimate is again a rather conservative estimate, but it must also be considered that some of this carbon can be found in the coarse roots and stump, too. Most of the carbon that is transferred from the roots to the soil is found in the topsoil layers, and the transfer takes place a few years after felling the trees, i.e. after the death of the roots. The full decomposition of most of this dead-wood-turned-soil-carbon may take decades.

Note that the emissions from dead roots due to decomposition are fully accounted for in the biomass pool as both gains due to increments and losses due to harvests and mortality are taken into account when estimating carbon stock changes of the biomass pool by using the stock change method.

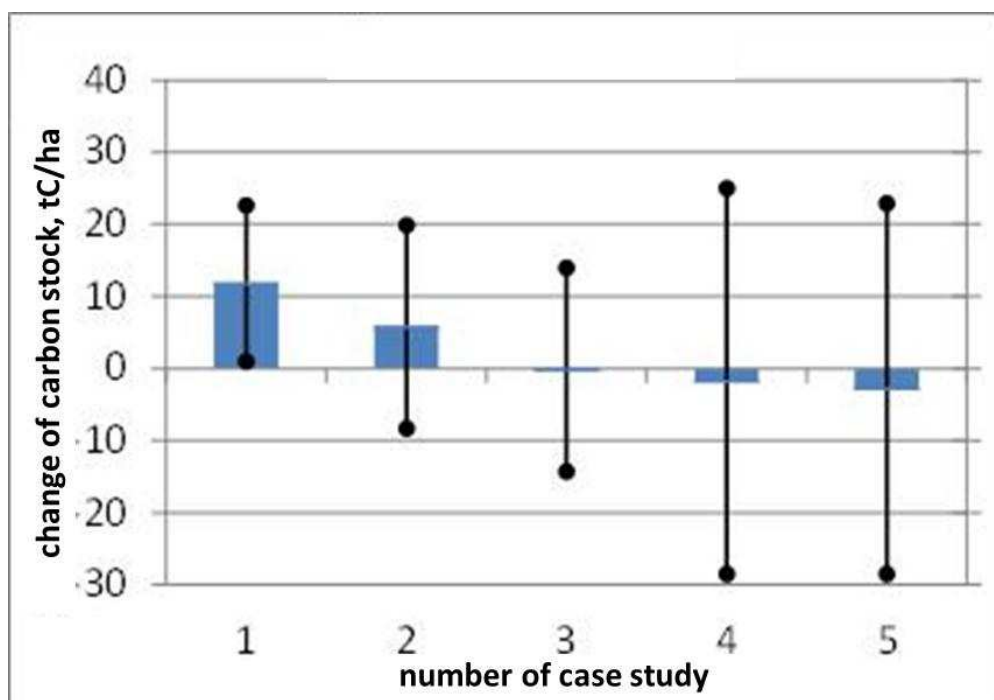
That carbon stocks of the soil do not decline much, rather, increase after regenerations, show that any emissions from soils due to direct human induced disturbances from soil preparation are much more than offset by the transfer of carbon from the dead roots to the soil. This is equivalent to saying that the rate of emissions from soils due to operations related to artificial regeneration is limited. However, these emissions could not be measured separately from gains due to transitions from dead roots to the soil, and remain to be rather uncertain.

Finally, it must be highlighted that most forest soils in Hungary, just like those elsewhere, are deeper than the 30 cm for which the estimation / demonstration of carbon stock changes must be done according to the IPCC methodology. The 30 cm are artificial, and has nothing to do with soil processes. Also, soil preparation may mix various soil layers, which may also result in an increase of soil carbon in plains where soil layers of relatively large organic content are covered by layers of lower soil organic carbon content (discussed to some extent in the Somogyi et al. 2011 report, but not here). Therefore, estimates and demonstration for the 30 cm layer may not have to do anything with actual processes.

The above would call for a substantial reduction of the rate of the specific emissions due to human induced disturbances that is applied in this demonstration. In order to stay conservative, however, we keep this rate at a still highly conservative value of  $5 \text{ tCha}^{-1}$  until further, although very improbable, evidence emerges that this rate is lower than actual emissions. (Note that, just like with all other strata, we apply a mean value here that applies to all stands of the stratum.)



**Figure 11.6.** Changes of carbon stock after artificial regeneration in sessile oak (*Quercus petraea*) stands of various years of age after regeneration in the top 30 cm of the mineral soil (litter and belowground dead wood are excluded). Columns show changes, and dots and lines show the 95% confidence interval of the changes. (Somogyi et al., 2011)



**Figure 11.7.** Changes of carbon stock after artificial regeneration in poplar stands of various years of age after regeneration in the top 30 cm of the mineral soil (litter and belowground dead wood are excluded). Columns show changes, and dots and lines show the 95% confidence interval of the changes. (Somogyi et al., 2011)

The area of this stratum is registered each year and is included in the statistics of the NFD. We note here that these statistics are for the entire forest area, and may include some forests of the FF category, thus, a bit smaller area should be considered here. However, as we do not have statistics for FF in this regard, we apply the entire area in the calculations for the sake of conservativeness.

The result of the estimation based on the above is that the annual net emissions, in 2010, from FM land since 1990 where final cutting and artificial regeneration following professional standards occur are 86 ktC (see also Table 11.3 below).

**Land under FM since 1990 where harvesting and natural regeneration is made following professional standards**

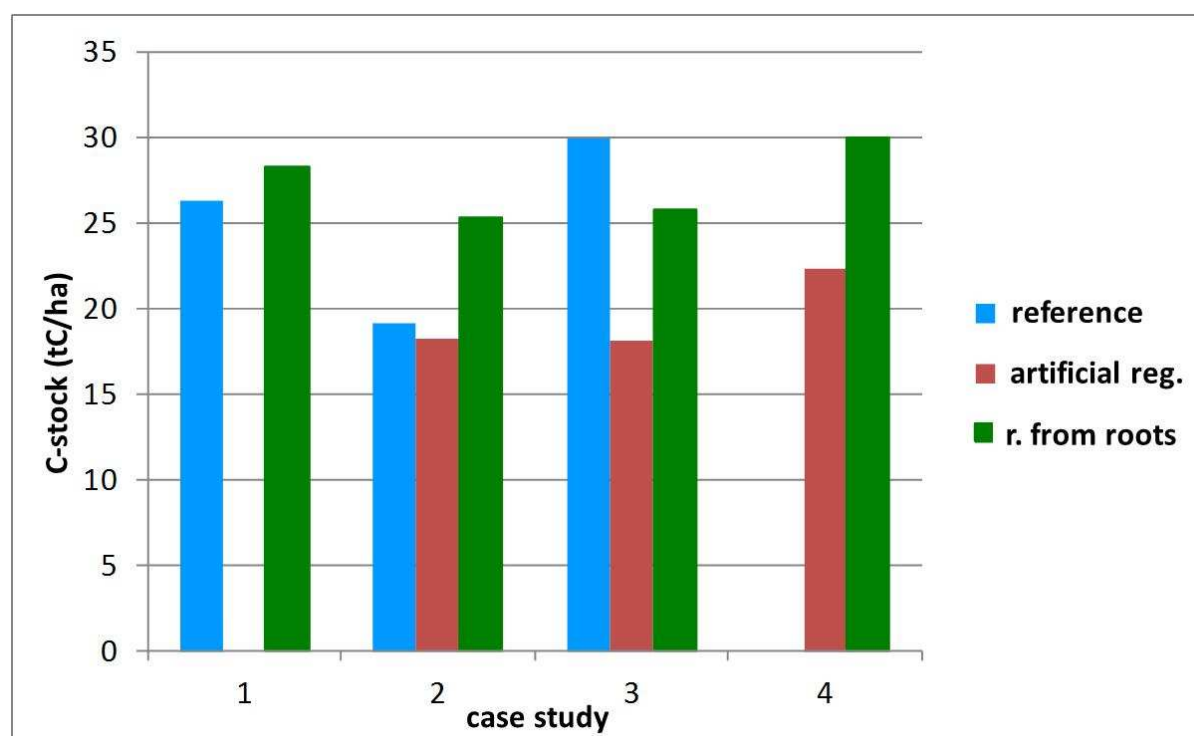
Natural regeneration here means that the area is regenerated exclusively through the propagation material that is locally produced by the trees of the mature stand. With a few exceptions, when seeds or seedlings from elsewhere are planted under the mature stand, and which sometimes involves some, but not intensive soil preparation, this type of regeneration usually makes it unnecessary to do any soil preparation, thus, only some small amounts of carbon may only be lost due to inevitable damages caused by removing timber from the area. However, this loss is assumed to be quickly offset by the growth of the dense new generation of trees, if not offset right away from the deadwood (mostly dead branches of harvested trees) and dead roots (of the same harvested trees) that is the result of harvesting the mature stand.

Because of the above, this stratum is assumed to have no overall emissions, i.e. a specific carbon loss of 0 tCha<sup>-1</sup>.

As with the previous stratum, the area of this stratum is registered each year and is included in the statistics of the NFD.

Here we again present a result from the above mentioned research project (Figure 11.8). We measured carbon stock changes of soils in several stands of Black locust, which is the most widespread tree species in Hungary. It seems that in stands where artificial regeneration took place, carbon stocks declined, however, regenerating the stands from roots resulted in both increase (in two case studies) and decrease (in one case study), or at least a much higher C stock than in the comparable stand after artificial regeneration (in the fourth case study). Thus, the above assumption is supported by some evidence.





**Figure 11.8.** Carbon stock of soil before (“reference”) and after regeneration (artificial regeneration: “artificial reg.”, and regeneration from roots: “r. from roots”) of chronosequences of Black locust stands in four case studies. (Somogyi et al., 2011)

**All other land under FM since 1990 that are between regeneration and the beginning of the subsequent regeneration and final cutting (i.e. the stages of the above strata), and that may be affected by normal silvicultural operations such as thinnings**

This stratum, by far the biggest one, includes all forests that cannot be classified into any of the previous categories. In these forests, the predominant process is the slow but steady growth of trees together with the associated slow but steady sequestration of carbon in the soil. These stands may occasionally and locally be disturbed by abiotic or biotic natural agents, or by thinnings, and some carbon may thus additionally be lost due to natural decomposition of dead biomass. However, these disturbances generally only affect trees but not the soil, the roots of the cut trees slowly decompose and some of their parts become part of the soil, and the overall balance of all these processes is a net gain.

Therefore, these areas will be assumed to have a rather small but positive net carbon stock change per unit area. The assumed value is a net removal of  $0.05 \text{ tCh}^{-1}$ .

Concerning the area of this stratum, it is calculated from the total forest area under the KP minus the sum of all of the above strata, which is equivalent to the total FM area minus the area of the two other strata of the FM category

The result of the estimation based on the above is that the annual net emissions, in 2010, from FM land since 1990 from stands that are between regeneration and the beginning of the subsequent regeneration and final cutting (i.e. the stages of the above strata), and that may be affected by normal silvicultural operations such as thinnings, have net removals of  $-81.7 \text{ ktC}$  (see also Table 11.3).

Total net emissions, in 2010, from FM land since 1990 amount to  $4.3 \text{ ktC}$  in 2010. The respective figures for 2008 and 2009 are removals of  $1.4 \text{ ktC}$  and  $4.9 \text{ ktC}$ , respectively. All values are very small, together varying around zero (with a mean value of about zero over

the three years), have a rather large uncertainty range, and are the results of a rather conservative estimation methodology. Especially because of the wide uncertainty range, the results cannot be proven to deviate from zero. Thus, it is demonstrated that FM land since 1990 as a whole has not been a source for the last three inventory years. A research project is under way to get even further information on removals of the last stratum (i.e., the mean removal rate of forests that are between regeneration and the beginning of the subsequent regeneration and final cutting).

The summary of the data for AR and FM, and all of the above strata for 2010 are found in **Table 11.3**. It is important to note that some of them come from scientific case studies, and some data are rather a combination of data and expert judgments but, as demonstrated above, are conservative estimates in order to demonstrate that the sum of all values are negative, i.e. total removals are greater than total emissions for both AR and FM.

The summary of all total data is thus a logical resultant of all data, and should only be regarded as a value of which only the sign is relevant and demonstrable here. In other words, the estimated total carbon stock change values are not regarded as accurate, and are not intended to be a basis for accounting, rather, they are only intended to serve the demonstration of the correctness of the assumption that soils are not a source.

**Table 11.3.** Area, emission and removal data for the various AR and FM strata and for their total in 2010. See text for details.

Forest Land Stratum under the KP		Estimated area	Emission (+) and removal (-) factor (IEF in italics)	Total emissions (+) or removals (-)
		(kha)	(tC ha <sup>-1</sup> )	(ktC)
Land under AR since 1990	that was converted from cropland	168.4*0.81 = 136.4	estimated using functions by Horváth, 2006 (corrected for 0-30 cm depth) and Somogyi et al. 2011	-44.6
	that was converted from grassland	168*0.19 = 32.0		3.2
	<b>Total</b>	<b>168.4</b>	<b>-0.25</b>	<b>-41.3</b>
Land under FM since 1990	where final cutting and artificial regeneration is made following professional standards	17.2	5	86
	where harvesting and natural regeneration is made following professional standards	4.4	0	0
	that are between regeneration and the beginning of the subsequent regeneration and final cutting, and that may be affected by normal silvicultural operations such as thinnings	1656.5 - 17.2 - 4.4 = 1634.9	-0.05	-81.7
	<b>Total</b>	<b>1656.5</b>	<b>0.0026</b>	<b>4.3</b>

We repeat that we selected the strata applied not only because they can match respective KP categories. Rather, we have data, first of all area data, but also carbon stock change information for these strata, which is necessary for accuracy, and the selected strata are also relevant from the point of view of processes that result in the estimated emissions and removals.

In order to further support the confidence in the above derivation, i.e. why the above reasoning leads to highly conservative estimates, and therefore, highly certain conclusions that soils are not a source in lands under all KP activities, we note the following additional arguments:

- Concerning the value applied for artificially regenerated land, the assumed value of 7.9 tCha<sup>-1</sup> for the stratum of artificial regenerations is the absolute maximum that one could assume based on the idea of completely converting forest to something else. However, even if regenerating (including tilling once) may mean high disturbance, no till certainly occurs continuously after the regeneration is done, which means that repeated emissions of ploughing are avoided in forests, thus, total carbon stock losses must be much smaller in forest land remaining forest land than converting a forest land to cropland. Even assuming an average rate of emissions of 5 tCha<sup>-1</sup> for *all* artificially regenerated stands seems to be a very high loss also given that there are many types of artificial regeneration applied, including ones that do not involve high-disturbance operations like ploughing. Currently, however, no statistics exist with respect to the share of the various regeneration types. According to experience, the operations leading to high emissions have been continuously replaced by less intensive ones (even due to economic reasons). The selected specific emission estimate of 5 tCha<sup>-1</sup> is with high probability a rather high overestimation for the sake of the demonstration only.
- The average rotation age of those Hungarian forests that exclude the AR since 1990 and FF areas, and where no final cutting/regeneration occurred in 2008, is about (1,912-162-94) kha /19.2 kha = 86.2 years. Assuming an annual soil carbon stock increase of 0.05 tCha<sup>-1</sup> in these areas after regeneration is equivalent to assuming a total sequestration of 4,23 tCha<sup>-1</sup> for this total average rotation period, which is only about 85% of the emissions (5 tha<sup>-1</sup>) that is assumed for these areas when they come to regeneration.
- This value of 0.05 tCha<sup>-1</sup> for a stratum under FM is a rather conservative estimate also if it is considered that the Horváth (2006) equation, which predicts a low rate of sequestration of after the age of 75, i.e. long after the afforestation, suggests that this lowest rate of increase (after the correction for the 30 cm soil depth as above), which may correspond to a rate in a “forest land remaining forest land”, is about double of the 0.05 tCha<sup>-1</sup> rate. The Somogyi et al. (2011) estimates are even much higher than that.
- It is documented in many scientific publications that forests accumulate C in their soil. We selected a rather comprehensive study published recently by Berg et al. (2007) that states that “The amount of carbon sequestered in humus increases in forests and it appears that the average rate for Sweden is of the magnitude 100 to 200 kg C ha<sup>-1</sup>yr<sup>-1</sup>.” (Note that this accumulation occurred in the humus layer of podsol soils, the depth of which never reached 12 cm.) Hungary is situated in a warmer region and has definitely higher tree growth rates, which involve higher ecosystem turnovers. Therefore, assuming a sequestration rate of 0.05 tCha<sup>-1</sup>yr<sup>-1</sup>, i.e. 50 kg C ha<sup>-1</sup> yr<sup>-1</sup>, is a highly conservative approach. It is also conservative, because this rate decreases over time, but is by far the highest for decades after disturbance, which is the latest regenerations of these stands that used to be artificial one most of the cases in the previous decades.
- We also note here that we also conducted a study to try to estimate this rate. However, this attempt, which included the carbon stock of 12 stands of similar site in a chronosequence proved to be inconclusive due to the high variation in soil parameters (Somogyi et al. 2011). According to a study conducted in Thuringen (Germany), where soil and forest conditions are similar, an annual rate of change in forest soils of 0.05 tha<sup>-1</sup>

can be detected by a 4x4 km soil monitoring only in a period of 82-96 years (Baritz et al., 2006).

- We highlight the fact that carbon stock change estimates are rather uncertain for both Hungary and any other country. This means that the uncertainty range of the above estimates, which cannot be quantified at the moment, is so wide that makes no accounting reasonable. This is one major reason we opted for the demonstration. Our demonstration is, however, heavily biased on the emission side, thus increasing the confidence in the final conclusion that soils are not a source.
- Finally, we note that, although we do not use our estimates in our accounting, the method of the above demonstration is capable of serving one important goal, which is the final goal of preparing greenhouse gas inventories, and which is to identify sources of emissions due to direct human induced activity in order that the impacts of these activities can be reduced. By having broadly identified such processes in our demonstration, we are now able to develop policies to reduce the emissions mentioned above.

All in all, by applying a method whereby all steps included conservative or even highly conservative estimates, we can conclude that the sum of all emissions and removals is negative for both AR and FM, i.e., we demonstrated that the Hungarian forests are not a source. By applying conservative values, and demonstrating how and why they are conservative ones, leads to a high level of confidence in the conclusion.

Finally, once again, all the above is only meant to demonstrate that the Hungarian forests are not a source. The final result of the reasoning is not meant to be interpreted as an accurate scientific estimate of the rate of removals, or values used for accounting emissions or removals under the KP.

### ***D DOM emissions***

The Hungarian forest health monitoring system, called Forest Protection Network (FPN), supplied some data on deadwood in years of 2010 and 2011. Since it refers only to two years, and data of these two year are not significantly different, we cannot estimate the changes of DOM pools in other categories (FM, AR), however, the data available are suitable for estimating of the emissions from D for 1985-2010. The total emission of carbon from deadwood on a D land is always accounted for in the year of deforestation. The average amount of deadwood in all Hungarian forests was found to be 11.49 m<sup>3</sup>/ha (this is the higher value from 2010), and this mean value is multiplied by the area of the deforestation to estimate the amount of wood from which CO<sub>2</sub> is assumed to be emitted. The carbon stock changes are estimated from the above volume using the methodology of stock change as detailed above (and note that the average wood density that is applied for the woody biomass is a conservative assumption, i.e. it leads to an overestimation of DOM emissions).

The FPN network works as a 4x4km systematic sampling with concentric permanent sample plots, and its 16x16km grid is part of the European level forest health monitoring Network (IPC Forest, Forest Focus, Life+ programs & FutMon Project).

Considering litter in D, we rely upon a case study published by Führer and Mátyás, who found that the average amount of carbon in litter is 3.2 t/ha, which amounts to some 1.5% of the whole carbon stock of Hungarian forests in general. (Note that the GPG suggests 28.2 t/ha as default for litter in mature warm temperate dry broadleaf forests, however, this value is unrealistically high for the Hungarian forests that are, on average, neither mature nor natural.)

The above average again was multiplied by the annual area of deforestation to develop emission estimates.

We note here that, because of the small scale of deforestations each year, and because LI and especially DW is a small carbon pool, this simple but anyway Tier 2 approach can be regarded as an accurate methodology as far as practicable.

***Demonstration that the deadwood and litter carbon pools are not a source on AR and FM land***

We currently do not have a monitoring that could provide accurate estimates for the amount of carbon stock or carbon stock change in the DW and LI pools on AR and FM land.

The below demonstration, which is in some respect a more detailed version of the assumption under the UNFCCC that the net emissions of these pools of all accounted forests (FM, AR, D) can be assumed to be zero, is based on some measurements, but mainly on sound scientific knowledge and reasoning.

**AR land**

When an area is afforested, first it is cleared of all above-ground biomass in case there was any, however, no DW and LI are usually present on these lands prior to afforestation. After afforestation, dead woody debris, litter as well as dead trees start to accumulate. In lack of representative measurements, the rate and timing of accumulation is not known, however, standard forestry experience suggests that they depend on species, site and silvicultural regime, and quickly accumulate over time. Fast growing species are usually planted so that no large amount of deadwood is produced, or thinned so that self-thinning does not ensue, but litter is continuously produced even in these stands. On the other hand, slow-growing species tend to produce dead wood and litter even at an early stage. Overall for all AR land, also considering that AR activity has been continuous since 1990 and stands on AR land are usually younger for deadwood and litter accumulation to saturate, it can safely be concluded that the carbon in the deadwood and litter pools in AR lands was increasing between 2008-2010, i.e. these pools are not a source.

The above demonstration is based upon well-established principles of forest science, the every-day experiences of forestry practice, the experience and data of forest surveys, as well as sound reasoning. Because of this, although no representative measurements have been made as mentioned, the level of confidence of the demonstration is suggested to be very high.

**FM land**

No intensive monitoring of DW and LI exists in Hungary. However, data on standing deadwood (i.e., most of the deadwood) is collected in a 4x4 km sampling grid of the European-wide, so called IPC Forest monitoring network (this grid was established in the 1980's, so almost all sampling points are found within the FM category). The FMOS program (Forest Monitoring and Observation System) took place 2009-2010 on the same 4x4 sampling grid also reports slightly increasing deadwood (see **Figure 11.4**).

According to the most recent estimates, the amount of the standing deadwood has increased by just under 1% during the period 2000-2005 (Figure 12 of Somogyi-Zamolodchikov, 2007). As the cited figure suggests, this value is in about the mid-range of similar data for other European countries.

This empirical data is also supported by field experience. The silvicultural approach changed in the last two decades, and stands of indigenous species are managed much more along the lines of the close-to-nature forestry principles than on the lines of plantation forestry (this process is related to our most recent Forest Acts, see section 7). This inevitably means leaving more deadwood in the forests than before, which continuously increases the amount, and thus the carbon stock, of deadwood. The same obviously applies to litter.

As for AR, the above demonstration is based upon well-established principles of forest science, the every-day experiences of forestry practice, the experience and data of forest surveys, as well as sound reasoning. Because of this, although only measurements of low representativity have been made so far, the level of confidence of the demonstration is suggested to be high.

#### **11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out**

According to the report of a rather recent IPCC meeting (Expert Meeting on Revisiting the Use of Managed Land as a Proxy for Estimating National Anthropogenic Emissions and Removals, 5-7 May 2009, Sao Paulo, Brazil), there are currently no scientifically sound methods to separate out indirect and natural GHG emissions and removal (IPCC, 2010). On the other hand, this is not necessarily needed if appropriate proxies are used. The above mentioned meeting, among others, stated that, although not perfect, the currently applied proxy, i.e. the so called “managed land” proxy is one that approximates the effects of direct human induced activities.

We also note that, especially for FM, this separation is taken care of by the various steps of the accounting, thus, no special separation is necessary, and we have indeed not have done any separation.

#### **11.3.1.4 Changes in data and methods since the previous submission (recalculations)**

See Chapter 7.3.6.

#### **11.3.1.5 Uncertainty estimates**

Uncertainties are associated with each step of the estimation of emissions and removals. Some of the uncertainties are already assessed above, and uncertainties are also covered to some extent in Chapter 7.3.4. Uncertainties are further assessed in a detailed procedure below.

It is underlined here, too, that it is due to the inherent uncertainties of our estimation procedure that we always take a conservative approach to avoid the underestimation of emissions and to minimize those sources of uncertainties that we are aware of. Thus, the most important aspect of uncertainty analysis is dealt with by applying the conservativeness principle. Another, by far not unimportant, aspect of dealing with uncertainties is to identify and quantify them. One principle in this identification and quantification is that we should first identify and quantify, and then prioritize uncertainties that could effectively be reduced by practicable policies and measures.

As for identification, we believe that the most important sources of uncertainties in the estimation of GHG emissions and removals due to the various KP activities include the following (the ones that are regarded less important are in brackets):

- identification of land under the various 3.3 and 3.4 activities over time
- growing stock and its changes
- basic wood density
- root-to-shoot ratio
- (carbon fraction of wood)
- carbon loss from soils, deadwood and litter due to forestry operations
- (forest fires and other disturbances within their normal, i.e. usual, range)

- forest fires and other disturbances outside their normal range.

We note here that the uncertainty of certain forest characteristics, e.g. the size of the area of land under the various activities, is unimportant in the process of estimating emissions and removals in our system because they do not directly enter the algorithm of the GHG estimation. Whether a land is identified or not, i.e. whether carbon stock changes on that land must be estimated or not, is, however, important, see the first bullet point above. In this respect, we believe that our data collection system results in an underestimation of removals and overestimation of emissions.

Also to be noted is that the above list is for both the country-level and the geographical location-level estimation, and certain elements of this list could be broken down to other elements, such as uncertainties of the steps of estimating wood volumes by stand etc. However, identifying uncertainties at these various sub-country levels would only be important if the uncertainty budget were developed bottom-up, i.e. from the uncertainties of these levels. Rather, we develop the uncertainties of the GHG inventory from the species level up, for which level we have estimated or assumed uncertainties.

With respect to measurements related to the biomass, the primary objective of the forest monitoring system in Hungary has been to obtain accurate information on the status and development of all forests in the country, and to assist forest management by developing forest management plans at the compartment and forest enterprise level. Thus, with respect to accuracy, the monitoring was designed to provide most accurate estimates at various aggregate levels. In addition, however, different levels of accuracy are applied to the individual sub-compartments depending on the age of the trees and the estimated amount and value (quality) of the growing stock. Due to needs for accurate emission and removal estimates from D, the monitoring system has been developed so that an accurate and detailed field survey is applied to areas to be deforested, thus, a fairly high accuracy has been achieved with respect to the biomass lost in deforestations.

Concerning the estimation of carbon stock changes on AR lands, it is noted that volume is estimated using yield tables, as well as ground surveys. Where the volume of the stand makes it practical to take field measurements, sampling and actual measurements are applied according to the forest monitoring protocol. The same way, where the growth of the stands is still slow and, due to the height of the trees and the thickness of the stand, it is simply impractical to take field measurements, the estimates of yield tables are used. Because of all the above, the emission and removal estimates for the AR lands can be regarded as accurate as far as practicable. Also, as mentioned before, a low root-to-shoot ratio is assumed for the AR, thus, below-ground biomass values are most probably underestimated. As long as AR land is a net sink, this yields a conservative estimation.

In order to quantify the combined uncertainties of those factors in the biomass-related GHG emissions and removals that were not covered above or for which unknown uncertainties may still exist, a detailed study is demonstrated below that involves a Tier 3 level Monte Carlo analysis.

With respect to land identification, the soil, deadwood and litter pools, as well as non-CO<sub>2</sub> emissions from forest fires and disturbances, we refer to section 7.3.4 of the NIR and the above sections of Chapter 11. The analysis below thus only covers the above-ground biomass (AB) and below-ground biomass (BB) pools.

Finally, it is noted that the effect of carbon fraction of the wood will not be analyzed due to its known and rather small effect on GHG estimates, and also because no policy could currently affect this fraction anyway.



## Methods

In order to analyze the possible effect of the uncertainties of the selected factors that were mentioned above, a detailed Monte Carlo analysis was conducted for the emission and removals estimates of the AR land. We believe that GHG estimates for land under the D and FM activities, and those for the geographical locations we apply, have similar relative uncertainties due to the fact that the various factors affect the GHG estimates practically the same way (i.e. following the same physical/biological/ecological laws) in each land or geographical location, and the methods applied in both the forest inventory and the GHG inventory are also basically the same for FM, AR and D.

In order to identify possible levels of combined uncertainties in biomass carbon stock change estimates, the following procedure was conducted:

- As a first step, we assume that there is no overestimation, i.e. no positive bias for lower values in the estimation of wood volume and wood volume increment. This is justified because there are some indications in the forest inventory that the traditional forest inventory underestimates wood volume and wood volume increment, but the rate of the underestimation is unknown yet. (This is equivalent to saying that the estimates are not accurate, however, they are certainly conservative.)
- There are indications also in a sample-based inventory, which is not fully implemented yet, that trees are growing faster than before, i.e. faster than in the growth models we apply. On the other hand, a small fraction of stands may have started to grow slower due to adverse effects of climate change, although there is no evidence for that so far. Overall, it seems that growth rates are underestimated, but the rate of this underestimation is unknown.
- As we do not currently have direct uncertainty estimates for our wood volume and wood volume increment estimates, we had to apply a model-based approach. In this approach, we apply the same yield tables that are applied in the forest inventory to estimate current annual increment (CAI), and silvicultural models (i.e. harvest models) that were developed by the end of the 1980's, and that fairly model harvests in the country.
- The greenhouse gas estimates in this uncertainty analysis are thus not derived using the stock change method, which is otherwise used in the GHG estimation, rather, using the Gain-Loss method (equation 2.7 of the IPCC, 2006 Guidelines).
- It is, however, assumed that the two approaches would yield similar results in terms of both the GHG estimation and the uncertainty estimation (and especially with respect to the share of the uncertainty of the various factors in their contribution to the overall uncertainty). This is achieved by assuming a normal error distribution, with appropriate standard deviation, of the CAI (see table below), but no errors (uncertainties) in the silvicultural model. In other words, we assume that the uncertainties that we apply for CAI would take care of the uncertainties of the harvests, i.e. for the difference between CAI and harvests, which is equal to the volume stock changes.
- We also assume normal error distributions and respective standard deviations for basic wood density and for the root-to-shoot ratio (see the table below).
- All carbon stock change calculations are done by applying an appropriate carbon accounting model that implements equation 2.7 of the IPCC (2006) Guidelines with the above forestry models. This model, CASMOFOR, which is published by Somogyi (2010) and is freely available from the internet (<http://www.scientia.hu/casmofofor>), is equipped with a Monte Carlo estimation module. Thus, the errors due to the above factors can be propagated in the calculations. In the Monte Carlo analysis, we repeated the calculations N=100 times in each separate analysis (see below).

- Finally, we assume that there is no correlation between the variables studied and their error distributions. This is justified because each variable has a physically/ecologically independent effect on the carbon stock changes.

For this analysis, we partly have country specific data (for basic wood density), partly we can assume uncertainties based on default values (for root-to-shoot ratio, in accordance with page 4.38 of IPCC 2003), and partly we have to apply expert judgements/assumptions (for wood volume change estimation). The relative standard deviations (STD) that are assumed and applied for the Monte Carlo analysis are summarized in Table 11.4.

**Table 11.4.** Assumed relative standard deviations for the variables that affect the uncertainty of the AB and BB pools.

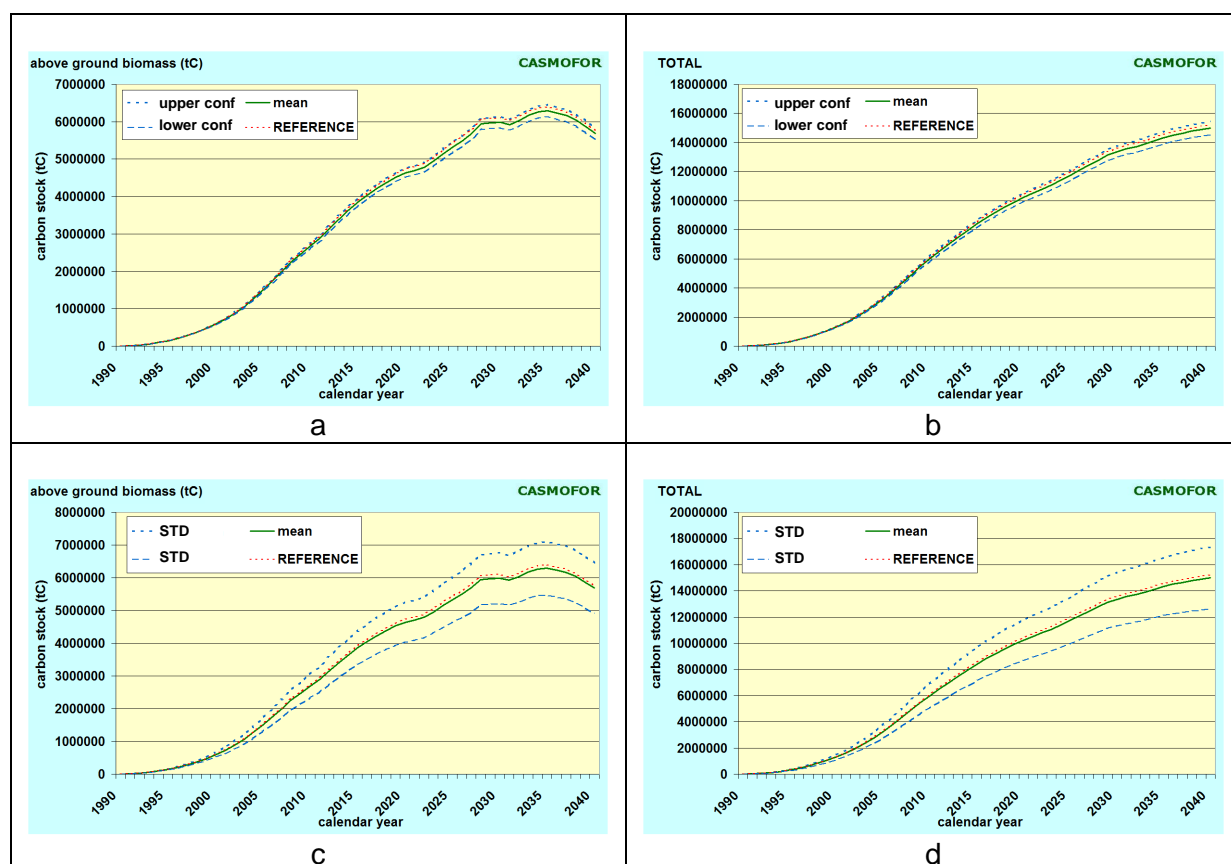
Variable	Assumed relative STD (%)	Source
CAI	20 %	Expert judgement; assumption
Basic wood density	10 %	Somogyi, 2008 who found relative STDs between 5.7-12.7%
Root-to-shoot ratio	30 %	Expert judgement; IPCC 2003 (page 3.31: uncertainty of root-to-shoot ratio is assumed to be 30%, which corresponds to an SRD of 30 %)

## Results

First, graphs are included below (Figure 11.9) that represent the quantified uncertainties due to the combined effect of the various factors on the carbon stocks. Each graph shows the development of the carbon stocks over time for the AR land as estimated by CASMOFOR. The green curves show the estimates without assuming any uncertainties (this could be regarded as “reference” curves when no uncertainties are assumed). The red-dotted curves are the mean values of the carbon stocks of all 100 runs of the Monte Carlo analysis. These curves are a bit different from the green ones, which may demonstrate the possible effects of the uncertainties as a whole, but also that the sample size has an effect, too.

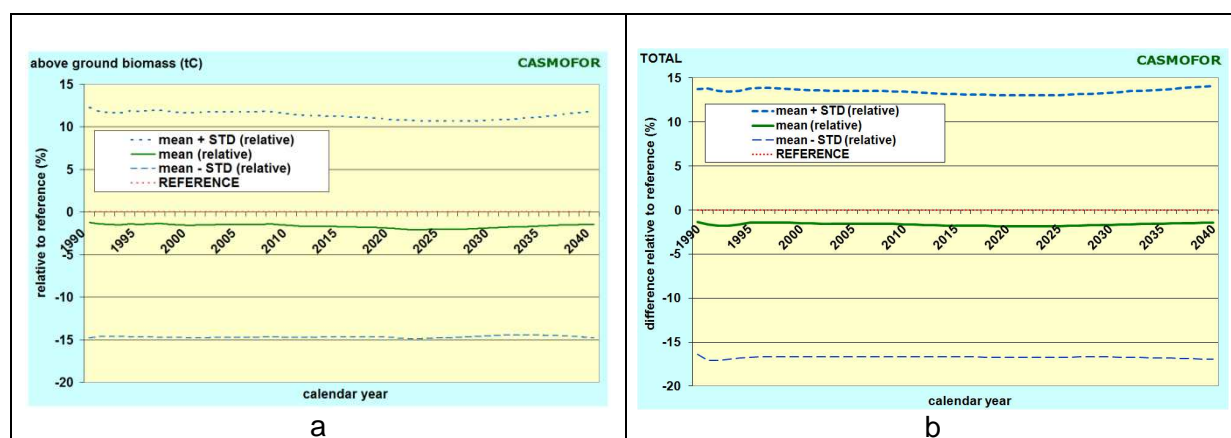
(In this analysis, it is assumed that no afforestation takes place after 2008. This is not true, but it was not necessary in this analysis to assume any afforestations beyond this year. This is the main reason that the curves level off after 3-4 decades, in reality, however, this would not happen as afforestations and reforestations have continued, and are planned to be continued, in future.)

The first two graphs in Figure 11.9 also show the confidence interval, at the 95% probability level, of the carbon stock estimates for the AB due to the variance of the perturbed variables. The CASMOFOR model, however, is also able to provide an estimate of the carbon stock of the entire forestry system that includes all carbon pools, i.e., in addition to the biomass pools, the carbon stock of the soil, litter, deadwood and wood products pools are also estimated. The development of the carbon stock and its confidence interval are shown in the second graph. We also present data for the entire system (“Total”), however, it is for information only. The second group of graphs in Figure 11.9 also shows, in addition to the reference and mean values, the  $\pm$  STD values around the mean carbon stock values.



**Figure 11.9.** Confidence intervals (at the 95% probability level, a and b) and standard deviations (STD, relative to the mean value of the simulation of 100 runs, c and d) over time for AB (a and c) and the total forestry system ("TOTAL", b and d) for the land under AR activities under the KP, as assessed by the Monte Carlo module of CASMOFOR

The next two graphs (Figure 11.10) show, over time, the standard deviation of the carbon stock *changes* due to the combined effects of all three variables studied relative to the reference level (calculated as a ratio of the STD to the reference carbon stock value, in %).



**Figure 11.10.** Standard deviations relative to the reference scenario carbon stock changes for AB (a) and, for information, for the total forestry system ("TOTAL", b) for the land under AR activity under the KP

The separate effects of the various factors can of course be analyzed the same way (**Table 11.5**), i.e. by analyzing STDs relative to the reference carbon stock changes. The data demonstrates that the uncertainty of CAI has the largest effect on the STD of the changes of both the AB and the total forestry system, whereas the root-to-shoot ratio has the largest

effect on the BB.

**Table 11.5.** *Separate and combined effect of the various factors (variables) on the STD of the carbon stock change estimate of AB, BB and all carbon pools (i.e. the above "TOTAL" forestry system), relative to the reference carbon stock change, for 2008 and for the land under AR under the KP, as assessed by the Monte Carlo module of CASMOFOR*

Variable	STD relative to the reference C stock change (%) in 2008		
	AB	BB	All carbon pools
CAI	11.8%	11.8%	12.3
Basic wood density	6.1%	6.1%	6.4
Root-to-shoot ratio	-	18.1%	3.6
<b>Combined effect:</b>	<b>13.5 %</b>	<b>25.1%</b>	<b>15.3%</b>

For AB, and for the inventory year 2008, the combined effect of the random errors of the variables studied amounts to an STD of 13,5% (**Table 11.5**), which, at the 95% probability level, corresponds to an uncertainty of

$$U_{AB} = 2 * STD * t(95\%; DF=99) / \sqrt{N} = 2 * 13.5\% * 1,984 / \sqrt{100} = \mathbf{5.36\%}$$

(DF = degrees of freedom).

For BB, and for the inventory year 2008, the relative STD is higher (**Table 11.5**), consequently, the uncertainty due to the combined effect of the random errors of the variables studied, calculated the same way, is also higher:

$$U_{BB} = 2 * 25.1\% * 1,984 / \sqrt{100} = \mathbf{9.96\%}.$$

The above calculations are based on data of our 2010 submission using data for 2008. As the overall data (e.g. total forest area) are not very different for 2009 and 2010, the results of the above analysis are still relevant. Finally, because it provides detailed and valuable information, the above uncertainty estimation will be used in developing the GHG inventory in the future.

### Error propagation

Uncertainty estimation was conducted by error propagation, too. The main principles of error propagation were introduced in Chapter 7.3.4, whereas a detailed description is available online at:

[http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/).

The results are shown in Table 11.6.

**Table 11.6.** Activity data, implied emission factor and combined uncertainties expressed by the half-width of percentage confidence intervals (confidence level = 95 %) by sink/source categories. Note that some confidence intervals have a half-width larger than 100 % in the case of wildfires on AR lands. This is due to methodological reasons because in negative direction the half-width can be maximum 100 %. For further explanation see the detailed methodological description at:

[http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/](http://www.mgszh.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/)

Category	Sink/source	Gas	Activity data	Implied emission factor	Combined
AR	biomass (stock-change)	CO <sub>2</sub>	0.67	58.07	58.07
AR	slash burning	CH <sub>4</sub>	4.48	25.75	26.14
AR	slash burning	CO	4.48	29.13	29.47
AR	slash burning	N <sub>2</sub> O	4.48	67.49	67.64
AR	slash burning	NO <sub>x</sub>	4.48	66.59	66.74
AR	wildfires	CH <sub>4</sub>	102.25	29.03	106.29
AR	wildfires	CO	102.25	36.44	108.55
AR	wildfires	N <sub>2</sub> O	102.25	105.04	146.59
AR	wildfires	NO <sub>x</sub>	102.25	103.51	145.50
D	deadwood	CO <sub>2</sub>	14.08	14.27	20.05
D	biomass (stock-change)	CO <sub>2</sub>	13.42	39.46	41.68
D	slash burning	CH <sub>4</sub>	13.37	17.10	21.71
D	slash burning	CO	13.37	19.23	23.42
D	slash burning	N <sub>2</sub> O	13.37	43.83	45.82
D	slash burning	NO <sub>x</sub>	13.37	43.25	45.27
FM	biomass (stock-change)	CO <sub>2</sub>	0.23	34.21	34.21
FM	slash burning	CH <sub>4</sub>	0.99	15.49	15.52
FM	slash burning	CO	0.99	17.52	17.55
FM	slash burning	N <sub>2</sub> O	0.99	40.53	40.54
FM	slash burning	NO <sub>x</sub>	0.99	39.99	40.00
FM	wildfires	CH <sub>4</sub>	45.98	23.11	51.46
FM	wildfires	CO	45.98	25.65	52.65
FM	wildfires	N <sub>2</sub> O	45.98	55.94	72.41
FM	wildfires	NO <sub>x</sub>	45.98	55.20	71.84

### Information on other methodological issues

It is important to highlight that, although we use the best methods and data that is currently available, and that often represent Tier 2 or 3, we are not able to accurately estimate carbon stock changes always using Tier 2 or 3. Therefore, a highly conservative approach is applied

in all steps of the inventory where the application of higher Tiers is not possible. This approach is characterized by always selecting data and methods that overestimate emissions and underestimate removals.

Generally, the area, harvest and forest fire statistics are based on annual assessments, whereas the emission factors and models applied are not based on the interannual variability of the physical environment. Therefore, the estimated emissions and removals are partly, but not completely, reflect the interannual variability of the true processes.

In principle, we use the same methods for estimating carbon stock change and non-CO<sub>2</sub> greenhouse gas emissions during the whole 1990-2010 period, thus, data reported under the KP is consistent with those under the UNFCCC. The same system, although with improved data coverage, is planned for the coming years, too.

With respect to the methodological Tiers applied in this report, at least the same or higher Tiers are applied as in our report under the UNFCCC. In general, higher tier, or at least methods of higher accuracy, are applied with respect to the identification and estimation of areas in the various land use and land use change categories under the KP. In general, too, Tier 2/3 is applied for AR, D and FM land: the land area identification is country-specific, and so is the estimation of volume, as well as that of the biomass conversion factor from volume to above-ground biomass. For the expansion of above-ground to total biomass, a Tier 1 factor is applied. The application of such a Tier 1 default factor is well compensated by selecting a conservatively low root-to-shoot factor, which may result in a bias in the estimation, but this bias is conservative as it is towards lower net removals.

With respect to QA/QC, the estimation, as well as QC has been done by the Forestry Directorate of the Central Agricultural Office, and the QA activities have been done by the Hungarian Forest Research Institute, in a similar fashion to the system applied for the preparation of the GHG inventory under the UNFCCC.

Almost all forestry data that have been used for the development of the GHG emission and removal estimates are collected, processed, aggregated and archived by the Forestry Directorate. Experts of the Directorate have participated in a training on the requirements and methods of developing the GHG inventory for the forestry sector. This system will ensure that all background data are collected and processed accordingly, and the number of possible sources of errors and uncertainties are reduced. On the other hand, the expert of the Hungarian Forest Research Institute, who has been involved in the QA activities, used to develop the GHG inventory for the country, thus, is very knowledgeable about the needs, method and challenges of the development of the inventory.

#### **11.3.1.6 The year of the onset of an activity, if after 2008**

The Kyoto CRF tables, as well as data and calculations as demonstrated above, clearly and transparently indicate both the areas and the associated emissions and removals under Article 3.3 that have entered the accounting system. For Art. 3.4 FM, activities on all land are assumed to be started before the beginning of the first commitment period. As a consequence, the Hungarian accounting system fully complies with paragraph 18 of the annex to decision 16/CMP.1.



## 11.4 Article 3.3

### 11.4.1 *Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced*

For D and AR, field certificates of conversions exist by stand for the majority of the stands. These are archived and documented. Such certificates are only prepared for conversions that are inspected and proved to have taken place, i.e. where human activity has indeed occurred. These certificates are in general documented since 1 January 1990. Also, forest management plans are prepared for all stands in the AR category (see under section 11.5.1).

### 11.4.2 *Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation*

In Hungary, all forests must be regenerated after clearing mature stands by law (as defined by all Forest Acts since 1879, the latest one in 2009). There are very few exceptions to this rule. Regeneration usually means that a cut-and-regeneration sequence of operations is applied, which involves that most of the area that is cut in a year is void of mature trees for many years. Moreover, regeneration may start one or two years after the final cut is made. When the regeneration is established, it may take years, even a decade, for the seedlings to reach a height of one-two meters, and a full crown closure. In general, less time is needed to reach a crown closure of 30%, but more time may be needed in parts of the regenerations where the first attempt is not successful (where samplings cannot establish themselves due to, e.g., bad weather conditions, weed competition, game browsing and others). In general, the rate of closure and whether an area is cleared (deforested) or is under regeneration can only be monitored in the field. There are country specific professional standards (as defined in the Implementation Rules of the Forest Act, 2009, practically unchanged for years) that set the time limits when regenerations (and afforestations) are deemed as successful.

According to the relevant decree, regeneration must be started not later than 31 May of the second year after land becomes subject to regeneration. "Successfulness" of regeneration means that it is believed that, except for rare extreme events, the regeneration continues to normally develop after it having been deemed successful and can already be regarded a forest. This stage is defined by the following:

- species composition is within the limits as requested by the forest management plan
- even distribution of trees
- healthy tree individuals
- the number of trees with main shoots is more than a minimum value required, usually eight thousand trees per hectare
- no invasive tree species in the stand
- minimum height of the main species reaches 1.5 m.

This stage is to be reached by time limits also defined by the above Rules. The time limits depend on species and site conditions and can vary quite substantially (see Table 11.7 below). All areas that had to be regenerated have always been regenerated within these limits so far. In case the regeneration of an area is unsuccessful, it becomes part of the D category.



**Table 11.7.** *Time limits of completing regenerations and afforestations (years after the area becomes subject to regeneration, e.g. after clearcutting)*

Species and Origin	Regeneration type: Shelterwood cutting or selection cutting, years
Quercus pubescens, seed origin	12
Quercus petraea, seed origin Quercus robur, seed origin Quercus farnetto, seed origin Fagus silvatica, seed origin	10
Other species, seed origin	8
	Other types of regeneration, years
Quercus pubescens, seed origin	14
Quercus petraea, seed origin Quercus robur, seed origin Quercus farnetto, seed origin Fagus silvatica, seed origin	12
Coniferous sp. Quercus cerris, seed origin Other hard broadleaves, seed origin	10
Other species, seed origin	8
Any species of shoot origin	5

All AR and D areas, as well as those under regeneration are identified by categorizing the above mentioned forest compartments. These compartments have been surveyed since 1 Jan 2008 for all information that is relevant for assigning them to the respective Kyoto forest categories (AR or D and, in case of regenerations, FM), as well as their location within each geographical area. It is also possible to identify each compartment in both the underlying database of this report (which is part of the documentation) and on the forest management maps since 2008.

Harvests on afforested area have so far only been final cuttings in stands that have reached their rotation age. In case an area is regenerated that was afforested or reforested earlier but after 1989, the same rules apply by law than for all other forests. These rules require that harvested forests must be regenerated. All areas under regeneration are continuously surveyed by the Forest Authorities, and tough penalties are applied to those that violate relevant provisions.

#### **11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested**

In Hungary, the Forest Authorities disclose a report each year on the current status of forests and forestry. This report includes the area of stands under regeneration. As **Table 11.8** below demonstrates, this area varies around 120 kha on average. The same reports also

state the area of final harvests each year which varied around 20-25 kha in the last three decades. From these numbers one can conclude that the average time a stand is regarded as “under regeneration” is about six years. Regeneration is basically treated the same way as afforestations and deforestations with regard to classifying them in a transition category such as “under regeneration. Thus, the above mean length of period of six years is regarded as a normal value for regenerations. (Note here, too, that individual stands can be classified “under regeneration” for a much shorter or longer time depending on species, site fertility, weather and other local conditions that determine the success of the regeneration.)

**Table 11.8.** *The total area of stands under regeneration as reported by annual reports on forests and forestry.*

Reporting Year	Area of stands under regeneration (ha)
1985	120,043
1986	126,120
1987	128,265
1988	130,333
1989	132,956
1990	132,816
1991	136,330
1992	135,582
1993	133,522
1994	127,611
1995	120,067
1996	116,716
1997	115,768
1998	112,926
1999	110,286
2000	112,814
2001	113,825
2002	115,740
2003	117,197
2004	117,855
2005	118,989
2006	119,854
2007	120,419
2008	123,717
2009	125,344
2010	127,783

### 11.4.3.1 The amount of harvests for units of land that have been harvested

We report in our NIR afforestation and reforestation areas that have been harvested. Just like on land under all activities under the KP, and on forest land under the UNFCCC, carbon stock changes on these areas are established using the stock change method. Nevertheless, to comply with relevant requirements for this information, we report the total amount of harvests on these areas in Table 11.9 below.

**Table 11.9.** *The amount of harvests for units of AR land that have been harvested (2008-2010). (Note that some data for 2008 have been corrected.)*

Reporting Year	Geographical Location	Amount of Harvests (m <sup>3</sup> )
2008	North Hungary	17,730
	South Hungary	70,125
	<b>Total</b>	<b>87,855</b>
2009	North Hungary	19,395
	South Hungary	98,001
	<b>Total</b>	<b>117,396</b>
2010	North Hungary	31,279
	South Hungary	83,494
	<b>Total</b>	<b>114,773</b>

## **11.5 Article 3.4**

### **11.5.1 *Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced***

Forest management plans are prepared for all forests of the country, i.e. all stands of both the AR and the FM category. These plans, which are parts of the underlying documentation, contain information, among others, on the status of the stand during the survey, long-term objectives, plans for short-term operations (for as long as a maximum 10-year period) and information on the last harvesting operations.

### **11.5.2 *Information relating to Forest Management***

#### **11.5.2.1 That the definition of forest for this category conforms with the definition in item 11.1 above**

FM land only includes managed forest areas that are included in the FL category, for which the definition of “forest” is applied as required by the Forest Act, as it is demonstrated above in section 11.1.

#### **11.5.2.2 That forest management is a system of practices for stewardship and use of forest land aimed at fulfill relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner (paragraph 1(f) of the annex to decision 16/CMP.1 (land use, land-use change and forestry))**

All the principles defined in paragraph 1(f) of the annex to decision 16/CMP.1 (land use, land-use change and forestry) are among the principles of forestry of Hungary as set by law. The text of the most recent Forest Act (in Hungarian) can be found at [http://www.mgszh.gov.hu/data/cms/132/407/Act\\_LIV\\_of\\_1996\\_eng.doc](http://www.mgszh.gov.hu/data/cms/132/407/Act_LIV_of_1996_eng.doc).

#### **11.5.2.3 Emissions and removals from Forest Management**

The methodology is described in the section 11.3.1.1, General methodological notes, and the estimated emissions and removals are reported in the KP CRF tables.

### **11.5.3 *Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year***

As Hungary elected neither Cropland Management, nor Grazing Land Management, nor Revegetation, this is a non-issue.

## 11.6 Other information

### **11.6.1      *Key category analysis for Article 3.3 activities and any elected activities under Article 3.4***

The following key categories have been identified and reported in Table NIR 3 according to Chapter 5.4 of the IPCC GPG for LULUCF:

- (1) CO<sub>2</sub> removals from Forest Management and
- (2) CO<sub>2</sub> removals due to Afforestation and Reforestation activities.

Deforestation is not considered as a key category as the total emissions from this activity is smaller than the smallest category considered key in the key category analysis under the Convention.

## 11.7 Information relating to Article 6

In Hungary, no Article 6 projects took place in 2008, 2009 and 2010.

## 11.8 NIR tables

TABLE NIR 1. SUMMARY TABLE

Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported <sup>(1)</sup>					Greenhouse gas sources reported <sup>(2)</sup>						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization <sup>(3)</sup>	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning <sup>(4)</sup>		
											CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
Article 3.3 activities	Afforestation and Reforestation	R	R	NR	NR	NR	NO			NO	IE	R	R
	Deforestation	R	R	R	R	R			R	NO	IE	R	R
Article 3.4 activities	Forest Management	R	R	NR	NR	NR	NO	NO		NO	IE	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

<sup>(1)</sup> Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

<sup>(2)</sup> Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

<sup>(3)</sup> N<sub>2</sub>O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N<sub>2</sub>O emissions from fertilization in the Agriculture sector.

<sup>(4)</sup> If CO<sub>2</sub> emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH<sub>4</sub>. Parties that include CO<sub>2</sub> emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table NIR 1.1 Additional information

Selection of parameters for defining "Forest" under the Kyoto Protocol

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.50
Minimum crown cover	10 - 30 %	30.00
Minimum height	2 - 5 m	5.00

Table NIR 2. LAND TRANSITION MATRIX

Areas and changes in areas between the previous and the current inventory year <sup>(1), (2), (3)</sup>

To current inventory  From previous inventory year		Article 3.3 activities		Article 3.4 activities			Other <sup>(5)</sup>	Total area at the beginning of the current inventory year <sup>(6)</sup>	
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)			Revegetation (if elected)
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	162.14	0.00					162.14	
	Deforestation		8.87					8.87	
Article 3.4 activities	Forest Management (if elected)		0.21	1,656.47				1,656.68	
	Cropland Management <sup>(4)</sup> (if elected)	NA	NA		NA	NA	NA	NA	
	Grazing Land Management <sup>(4)</sup> (if elected)	NA	NA		NA	NA	NA	NA	
	Revegetation <sup>(4)</sup> (if elected)	NA			NA	NA	NA	NA	
Other <sup>(5)</sup>		6.26	0.00	0.00	NA	NA	NA	7,469.31	7,475.57
Total area at the end of the current inventory year		168.40	9.08	1,656.47	NA	NA	NA	7,469.31	9,303.26

<sup>(1)</sup> This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management.

<sup>(2)</sup> Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

<sup>(3)</sup> In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

<sup>(4)</sup> Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

<sup>(5)</sup> "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

<sup>(6)</sup> The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country and is constant for all years.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS <sup>(3)</sup>
		Associated category in UNFCCC inventory <sup>(1)</sup> is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory <sup>(1), (4)</sup> (including LULUCF)	Other <sup>(2)</sup>	
Specify key categories according to the national level of disaggregation used <sup>(1)</sup>					
Afforestation and Reforestation	CO2	Conversion to forest land	Yes	NO	Removal of the category exceeds the emissions of the smallest category identified as key in the UNFCCC inventory.
Forest Management	CO2	Forest land remaining forest land	Yes	NO	Removal of the category exceeds the emissions of the smallest category identified as key in the UNFCCC inventory.
Deforestation	CO2	Conversion to cropland, Conversion to grassland, Conversion to settlements	No	NO	Removal of the category does not exceed the emissions of the smallest category identified as key in the UNFCCC inventory.

<sup>(1)</sup> See section 5.4 of the IPCC good practice guidance for LULUCF.

<sup>(2)</sup> This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.

<sup>(3)</sup> Describe the criteria identifying the category as key.

<sup>(4)</sup> If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.



## 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_2012_1_13-35-30 12-1-2012.xls]. (Report R-1)
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	There have been 22 transactions that resulted in one or more response codes instead of completing successfully during the reporting period, pursuant to 15/CMP.1 annex I.E paragraph 12. Please note, that all transactions with any response codes are reported despite the fact that none of the reported response codes are in the table named "Applicable DES Response Codes" under Appendix 2 of the document titled "SIAR Reporting Requirements and Guidance for Registries v4.5" Detailed information can be found in the Excel file named [SIAR Reports 2011-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 2011. The above statement can also be found in the Excel file named [SIAR Reports 2011-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 2011. The above statement can also be found in the Excel file named [SIAR Reports 2011-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 2011. The above statement can also be found in the Excel file named [SIAR Reports 2011-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.

<p>15/CMP.1 annex I.E Publicly accessible information</p>	<p>The public site of the registry is available at <a href="http://www.hunetr.hu">www.hunetr.hu</a>. The site and information is available both in English and Hungarian.</p> <p>Detailed availability of public information:</p> <ul style="list-style-type: none"> <li>- Account information http:\\www.hunetr.hu\\reportAccountsList.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Account List' from the menu on the left; the 'Search' button needs to be pressed to get results]</li> <li>- Article 6 project information http:\\www.hunetr.hu\\reportProjectList.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Project List' from the menu on the left; the 'Search' button needs to be pressed to get results]</li> <li>- http:\\www.hunetr.hu\\reportAccountHoldings.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Account Holdings' from the menu on the left; the search criteria fields can be set to get a custom result; by clicking the account id in the table named 'List of Accounts', detailed unit block information is shown]</li> <li>- http:\\www.hunetr.hu\\reportTransactionInformation.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; AAU related information is shown in fields 'Assigned Amount' and 'AAUs Issued' near the top of the page]</li> <li>- http:\\www.hunetr.hu\\reportProjectList.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Project List' from the menu on the left; the 'Search' button needs to be pressed to get results; on the result list click 'Conversions' on the right side of the table] OR http:\\www.hunetr.hu\\reportTransactionInformation.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; ERU conversion related information is shown in table named 'Emission Reduction Units']</li> <li>- http:\\www.hunetr.hu\\reportTransactionInformation.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; acquired units related information is shown in table named 'External Transfers']</li> <li>- http:\\www.hunetr.hu\\reportTransactionInformation.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; RMU issuance related information is shown in table named 'Removal Units']</li> <li>- http:\\www.hunetr.hu\\reportTransactionInformation.do [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'-</li> </ul>
---	--

	<p>'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; cancellation related information is shown in table named 'Cancellation']</p> <ul style="list-style-type: none"> <li>- <a href="http://www.hunetr.hu/reportTransactionInformation.do">http://www.hunetr.hu/reportTransactionInformation.do</a> [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; retirement related information is shown in table named 'Retirement']</li> <li>- <a href="http://www.hunetr.hu/reportTransactionInformation.do">http://www.hunetr.hu/reportTransactionInformation.do</a> [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Transaction Info' from the menu on the left; after selecting the year, the 'Search' button needs to be pressed to get results; if existed, carry over related information would be shown in table named 'Carry Over']</li> <li>- List of legal entities authorized by the Party <a href="http://www.hunetr.hu/reportLegalEntities.do">http://www.hunetr.hu/reportLegalEntities.do</a> [at <a href="http://www.hunetr.hu">www.hunetr.hu</a> choose 'Public Reports'- 'Unit Holding Rules Per Account Type' from the menu on the left]</li> </ul>
15/CMP.1 annex I.E paragraph 18 CPR Calculation	<p>The commitment period reserve is calculated in accordance with the annex to decision 18/CP.7, based on the inventory of 2010 (NIR submission 2012) Please see Ch. 12.1. for CPR and details of the calculation.</p>

## 12.1 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 2009 (National Inventory Submission 2011), however the inventory of 2010 (National Inventory Submissions 2012) is already available and by the time this document will be assessed, the inventory of 2010 might already be the "most recently reviewed inventory", so CPR is calculated based on 2010's data.

Calculations:

(a) On the basis of assigned amount:

90% of the assigned amount of Hungary  
 $542,366,600 \times 0.9 = 488,129,940 \text{ Mg CO}_2\text{-eq}$

(b) On the basis of the inventory of 2010 (NIR 2012)

five times the inventory of 2010  
 $67,679,050 \times 5 = 338,395,251 \text{ Mg CO}_2\text{-eq}$

## 12.2 KP-LULUCF accounting

Hungary was eligible to issue 3,943,732 RMUs based on the reviewed inventory of year 2008 as it is presented in the SEF report.

Altogether, based on the latest KP-LULUCF inventory, Hungary expects to be able to issue 8,796,303 tonnes CO<sub>2</sub> equivalent as RMUs and cancel 167,775 AAUs due to activities in 2008, 2009 and 2010 under Articles 3.3 and 3.4 of the Kyoto Protocol.

INFORMATION TABLE ON ACCOUNTING FOR ACTIVITIES UNDER ARTICLES 3.3 AND 3.4 OF THE KYOTO PROTOCOL

☐ Commitment period accounting: NO  
☐ Annual accounting: YES

HUNGARY  
 Inventory 2010  
 Submission 2012 v1.4

Number of the reported year in the commitment period: 3

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES		Net emissions/removals(1)				Accounting Parameters <sup>(7)</sup>	Accounting Quantity <sup>(8)</sup>
		BY(5)	2008	2009	2010		
		(Gg CO <sub>2</sub> equivalent)					
A. Article 3.3 activities							
A.1. Afforestation and Reforestation							-3,479.64
A.1.1. Units of land not harvested since the beginning of the commitment period <sup>(2)</sup>		-1,087.47	-1,060.55	-1,175.28	-3,323.29		-3,323.29
A.1.2. Units of land harvested since the beginning of the commitment period <sup>(2)</sup>							-156.35
Southern-Hungary		-21.39	-36.98	-69.25	-127.62		-127.62
Northern-Hungary		-4.03	-9.56	-15.14	-28.73		-28.73
All regions		IE,NO	IE,NO	IE,NA,NO	IE,NA,NO		IE,NA,NO
A.2. Deforestation		41.49	81.47	44.82	167.78		167.78
B. Article 3.4 activities							
B.1. Forest Management (if elected)		-2,784.02	-1,891.82	-1,679.71	-6,355.56		-5,316.67
3.3 offset <sup>(3)</sup>						0.00	0.00
FM cap <sup>(4)</sup>						5,316.67	-5,316.67
B.2. Cropland Management (if elected)	0.00	NA	NA	NA	NA	0.00	0.00
B.3. Grazing Land Management (if elected)	0.00	NA	NA	NA	NA	0.00	0.00
B.4. Revegetation (if elected)	0.00	NA	NA	NA	NA	0.00	0.00

## 13 Information on changes in national system

There were no significant changes as regards the main elements of the national system such as the single national entity and the compiler institutes. Nevertheless, it is worth mentioning that as of January 2012 the Hungarian Energy Office has taken over the role of energy statistics provider from the Energy Centre.

## 14 Information on changes in national registry

Changes to Hungary's National Registry are reported for the following period: from 16 April 2011 to 15 April 2012.

The baseline for the reported changes is the latest Standard Initial Annual Report (submitted on 15 April 2011) and the Readiness Documentation. Changes to the national registry during the reporting period are detailed below. The reported information has been compiled in accordance with the provisions of the "SIAR Reporting Requirements and Guidance for Registries (v4.5)".

In the reporting period there have been no significant changes to the Hungarian registry. Since late April 2011 SMS transaction signing system is implemented to the registry. Upon initiation of a transaction, the user who initiated the transaction receives a one-time code to his/her mobile phone, which needs to be entered before the transaction is processed.

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. Contact information of the registry administrator has changed. For details please see section 14.1 of this document.
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	No change to database or the capacity of National Registry
15/CMP.1 annex II.E paragraph 32.(d) Change of conformance to technical standards	No change in conformance to technical standards
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 list of publicly available information in the reporting period.
32.(h) Change of Internet address	Hungary's National Registry's Internet address is unchanged. The address is: <a href="http://www.hunetr.hu">www.hunetr.hu</a>
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	No change in test results
The previous Annual Review recommendations	The latest Annual Review had recommendations regarding the publicly available information. All issues have been corrected. For details please see information in the table above under "Publicly accessible information"

## 14.1 Change in contact details of the Registry Administrator

The change in the contact details of the Registry Administrator is the following:

The primary contact is:

Name: Mrs. Jánosné Tolnai Dr.  
Position: Deputy General Manager  
Organization: National Inspectorate for Environment,  
Nature and Water  
Address: Mészáros utca 58/a  
City: H-1016 Budapest  
Tel.: +36 12 24 9100  
Fax: +36 12 24 9264  
E-mail: [tolnai.janosne@oktvmf.gov.hu](mailto:tolnai.janosne@oktvmf.gov.hu)

Further contacts are:

Name: Ms. Livia Víg  
Position: Expert  
Organization: National Inspectorate for Environment,  
Nature and Water  
Address: Mészáros utca 58/a  
City: H-1016 Budapest  
Tel.: +36 12 24 9199  
Fax: +36 12 24 9264  
E-mail: [vig.livia@oktvmf.gov.hu](mailto:vig.livia@oktvmf.gov.hu)

## 15 Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

Information on how Hungary as a Party included in Annex I of the Convention is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement her commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

In accordance with Article 3, paragraph 1 of the Kyoto Protocol Hungary is committed to limit her anthropogenic carbon dioxide equivalent emissions of greenhouse gases listed in Annex A of the Protocol to such level that they are in line with Hungary's reduction targets while aiming at further emission reduction. Hungary is guided by the principle that ambitious national reduction targets shall be supported by a climate policy ensuring that adverse impacts on developing countries, such as carbon leakage are avoided. Hungary fully supports the endeavors, measures and implements regulations of the European Union targeting the avoidance of such impacts and fostering sustainable development, while in the same time also a specific policy framework has been put into practice.

The Copenhagen Accord states the following:

„The collective commitment by developed countries is to provide new and additional resources, including forestry and investments through international institutions, approaching USD 30 billion for the period 2010 - 2012 with balanced allocation between adaptation and mitigation. Funding for adaptation will be prioritized for the most vulnerable developing countries, such as the least developed countries, small island developing States and Africa.”

In the spirit of the above, Hungary made a commitment of 6 Million EUR for 2010-2012. (2010: 1 M, 2011: 2 M, 2012: 3 M)

The policy framework is laid down in Hungary's National Climate Change Strategy (NCCS) for the period 2008-2025, based on extensive scientific research, a wide public consultation process and impact assessment. The strategy adopted in February 2008 by the Hungarian Government guarantees that according to the principle of integration, climate policy is integrated into development policy as well, safeguarding that emission mitigation projects, cooperation fostering technological transfer and enhanced funding options for climate change related projects will play an integral role among future development projects. Climate research shall be integrated into other scientific studies and research activities and the business sphere shall be involved in climate friendly investments in developing countries.

For the time being Hungary does not take part in large scale development projects relating to climate change.