



**Hungarian Meteorological Service**  
Greenhouse Gas Inventory Division

# **National Inventory Report for 1985-2012**

**Hungary**

May 2014

**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

Attila Kovács,  
external expert  
Katalin Lovas, expert

## LULUCF

## Forest Land

Péter Kottek  
Éva Ilona Király  
Dr. Zoltán Somogyi,

non-Forest  
Land

Dr. József Zsembeli,  
external expert  
Katalin Lovas, expert

## Waste

Gábor Kis-Kovács

## CONTENT

<b>EXECUTIVE SUMMARY.....</b>	<b>5</b>
<b>1. INTRODUCTION.....</b>	<b>10</b>
1.1 BACKGROUND INFORMATION AND CLIMATE CHANGE.....	10
1.2 INSTITUTIONAL ARRANGEMENTS .....	11
1.3 INVENTORY PREPARATION.....	13
1.4 DATA COLLECTION, PROCESSING AND STORAGE.....	14
1.5 BRIEF GENERAL DESCRIPTION OF METHODOLOGIES AND DATA SOURCES USED .....	16
1.6 KEY SOURCE CATEGORIES .....	17
1.7 QA/QC INFORMATION.....	20
1.8 UNCERTAINTY .....	22
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) .....	71
3.4 REFERENCES .....	82
<b>4. INDUSTRIAL PROCESSES (CRF SECTOR 2.).....</b>	<b>84</b>
4.1 OVERVIEW OF SECTOR.....	84
4.2 EMISSION TRENDS.....	85
4.3 MINERAL PRODUCTS (CRF SECTOR 2.A).....	89
4.4 CHEMICAL INDUSTRY (CRF SECTOR 2.B) .....	102
4.5 METAL PRODUCTION (CRF SECTOR 2.C) .....	110
4.6 OTHER PRODUCTION (CRF SECTOR 2.D).....	117
4.7 PRODUCTION OF HALOCARBONS AND SF <sub>6</sub> (CRF SECTOR 2.E).....	117
4.8 CONSUMPTION OF HALOCARBONS AND SF <sub>6</sub> (CRF SECTOR 2.F).....	117
4.9 OTHER (CRF SECTOR 2.G).....	139
4.10 REFERENCES .....	141
<b>5. SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3.) .....</b>	<b>144</b>
5.1 OVERVIEW OF THE SECTOR.....	144
5.2 PAINT, SOLVENT AND OTHER PRODUCT USES (CRF SECTOR 3.A, 3.B, 3.C).....	145
5.3 USE OF N <sub>2</sub> O (CRF SECTOR 3.D).....	147
<b>6. AGRICULTURE (CRF SECTOR 4) .....</b>	<b>149</b>
6.1 OVERVIEW OF SECTOR.....	149
6.2 ENTERIC FERMENTATION (CRF SECTOR 4.A).....	163
6.3 MANURE MANAGEMENT (CRF SECTOR 4. B.) .....	178
6.4 RICE CULTIVATION (CRF SECTOR 4.C.) .....	192
6.5 AGRICULTURAL SOILS (CRF SECTORS 4.D.1, 4.D.2 AND 4.D.3) .....	193
6.6 PRESCRIBED BURNING OF SAVANNAS (CRF SECTOR 4.E) .....	204
6.7 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF SECTOR 4.F).....	204
6.8 REFERENCES .....	206
<b>7. LAND-USE, LAND-USE CHANGE AND FORESTRY (CRF SECTOR 5).....</b>	<b>209</b>
7.1 OVERVIEW OF SECTOR.....	209
7.2 LAND AREA REPRESENTATION USED IN THE HUNGARIAN INVENTORY .....	213
7.3 FOREST LAND (CRF SECTOR 5.A) .....	222

7.4	CROPLAND (CRF SECTOR 5.B)	253
7.5	GRASSLAND (CRF SECTOR 5.C)	269
7.6	WETLANDS (CRF SECTOR 5.D)	279
7.7	SETTLEMENTS (CRF SECTOR 5.E)	287
7.8	OTHER LAND (CRF SECTOR 5.F)	296
7.9	NON-CO <sub>2</sub> EMISSIONS	297
7.10	UNCERTAINTY AND TIME-SERIES CONSISTENCY	299
7.11	SECTOR SPECIFIC QA/QC AND VERIFICATION	302
7.12	SECTOR SPECIFIC RECALCULATION	303
7.13	SECTOR SPECIFIC PLANNED IMPROVEMENTS	304
7.14	SOURCES - REFERENCES	305
<b>8.</b>	<b>WASTE (CRF SECTOR 6)</b>	<b>308</b>
8.1	OVERVIEW OF SECTOR	308
8.2	SOLID WASTE DISPOSAL IN LANDFILLS (CRF SECTOR 6.A)	310
8.3	WASTEWATER TREATMENT (CRF SECTOR 6.B)	317
8.4	WASTE INCINERATION (CRF SECTOR 6.C)	323
8.5	COMPOSTING (CRF SECTOR 6.D)	325
<b>9.</b>	<b>OTHER (CRF SECTOR 7.)</b>	<b>326</b>
<b>10.</b>	<b>RECALCULATIONS AND PLANNED IMPROVEMENTS</b>	<b>327</b>
10.1	EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS AND THEIR IMPLICATIONS FOR EMISSION LEVELS AND TRENDS	327
10.2	ENERGY SECTOR	327
10.3	INDUSTRY SECTOR	335
10.4	AGRICULTURE SECTOR	343
10.5	LULUCF SECTOR	345
10.6	WASTE SECTOR	346
10.7	PLANNED IMPROVEMENTS	347
<b>PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1.</b>		<b>348</b>
<b>11.</b>	<b>KP-LULUCF</b>	<b>348</b>
11.1	GENERAL INFORMATION	348
11.2	LAND-RELATED INFORMATION	356
11.3	ACTIVITY-SPECIFIC INFORMATION	360
11.4	ARTICLE 3.3	383
11.5	ARTICLE 3.4	387
11.6	OTHER INFORMATION	388
11.7	INFORMATION RELATING TO ARTICLE 6	388
11.8	NIR TABLES	389
<b>12.</b>	<b>INFORMATION ON ACCOUNTING OF KYOTO UNITS</b>	<b>391</b>
12.1.	CALCULATION OF THE COMMITMENT PERIOD RESERVE (CPR)	392
12.2.	KP-LULUCF ACCOUNTING	392
<b>13.</b>	<b>INFORMATION ON CHANGES IN NATIONAL SYSTEM</b>	<b>394</b>
<b>14.</b>	<b>INFORMATION ON CHANGES IN NATIONAL REGISTRY</b>	<b>394</b>
<b>15.</b>	<b>INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14</b>	<b>398</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 as laid down by a government decree. Also, other institutions and external experts are involved in the process of inventory preparation, e.g. the Hungarian Central Statistical Office, Hungarian Energy and Public Utility Regulatory Authority, Szent István University, Gödöllő, Karcag Research Institute of University of Debrecen, just to name a few. The participation of the Forestry Directorate of the National Food Chain Safety Office (NFCO, Forestry Directorate), formerly named Central Agricultural Office together with the NARIC 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 1985-2012. 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 2012, total emissions of greenhouse gases in Hungary were **62.0 million tonnes** carbon dioxide equivalents (excluding the LULUCF sector) which is *the lowest value* in the whole time series (1985-2012). Taking into account also the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 57.6 million tonnes CO<sub>2</sub> eq. in 2012. 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 45.8% lower than in the base year (average of 1985-87). For the most part, this significant reduction was mainly a consequence of the regime change in Hungary (1989-90) which brought in its train radical decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors like energy, industry and agriculture. Then, between 2005 and 2012, after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 20.9 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. After a quite significant drop of 8.7% between 2008 and 2009, our emissions in the following four years

(2009-12) remained the lowest in the entire time series. Although the decline in economic output stopped in the first quarter of 2010, Hungary had not yet reached the GDP level of 2008, moreover, our economy has shrunk again a little in 2012.

The most important greenhouse gas is carbon dioxide accounting for 74.3% 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 45.4% since the middle of the 80's. Methane represents 12.9% 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 by 36.8% lower than in the base year. Nitrous oxide contributes 10.9% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N<sub>2</sub>O emissions are 60.5% lower compared to base year. The total emissions of fluorinated gases amount to 1.9% but their steadily growing tendency seems to level off since 2008. However, special attention is still needed as their applications in the cooling industry and the use of SF<sub>6</sub> in electrical equipments, first of all in switchgears for insulation and arc quenching are still popular.

**Table ES.1** Trend of emissions by GHGs (excluding LULUCF, Gg CO<sub>2</sub> eq)

	BY	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO <sub>2</sub>	84,378	72,475	61,330	58,081	59,946	56,700	51,029	51,668	49,859	46,072
CH <sub>4</sub>	12,638	11,876	9,262	9,314	8,620	8,286	8,164	8,156	7,986	7,990
N <sub>2</sub> O	17,089	12,893	7,508	8,466	8,680	7,077	6,615	6,540	6,824	6,757
HFCs	0	0	38	237	682	986	944	1,039	1,145	1,006
PFCs	268	271	167	212	210	4	3	1	2	1
SF <sub>6</sub>	73	88	170	195	238	276	221	235	220	153
<b>Total</b>	<b>114,447</b>	<b>97,603</b>	<b>78,475</b>	<b>76,504</b>	<b>78,376</b>	<b>73,328</b>	<b>66,976</b>	<b>67,638</b>	<b>66,034</b>	<b>61,981</b>

Base year=average of 1985-87

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

By far, the biggest emitting sector was the energy sector contributing 73.4% to the total GHG emission in 2012. Agriculture was the second largest sector with 14.0% while emissions from industrial processes (with solvent and other product use) accounted for 7.5% and the waste sector contributed 5.1%. Compared to the base year, emissions were significantly reduced in the energy (-44.1%), agriculture (-53.2%), and industrial processes (-63.2%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+20.8%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior. Looking at the most recent trends since 2005, emissions have significantly decreased in the energy and industrial processes sectors by 21.4% and 43.1%, respectively. Somewhat smaller reductions occurred in agriculture (-4.7%), and the growing trend turned back also in the waste sector (-9.7%).

The **energy sector** was responsible for 73.4% of total GHG emissions in 2012. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.2% to the sectoral emission. Considering fuel use in combustion processes, gases had the highest proportion (48.9%), liquids and solids represented 26.6% and 14.2%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 9.5%. The most important subsector was energy industries with a proportion of 36.4% within the energy sector, followed by other sectors (26.1%) and transport (23.9%). Fugitive emissions from fuels played only a small role with 4.9% out of which 71.1% 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 emissions.

Overall emissions from the energy sector have decreased by 7.5% or 3.7 million tonnes between 2011 and 2012. The biggest change occurred in the "other sectors" (-13.2% or -1.8 million tonnes) mainly because natural gas consumption dropped by 13.5%. Commercial and public services purchased 20% less natural gas than in previous year, and we have not seen such a low consumption in the residential sector since the early 90's. Gross electricity production fell back by a further 3.9% (after a drop of 3.7% in 2011). Moreover, the decrease in natural gas based electricity production was the most pronounced (-12%), whereas the share of CO<sub>2</sub> neutral nuclear fuel has steadily grown in the last few years, and wind energy utilization showed a steep increase. In addition, electricity import grew significantly by 16% in 2012. Emissions from transport continued to decrease (-4.8%). Transport related emissions almost doubled between 1994 and 2007, since then, however, a decrease of 17.1% could be observed. Motor gasoline use has never been lower since 1990 than in 2011-2012, and road diesel consumption fell back as well (-7.9%). In addition, energy consumption of manufacturing industries decreased by 16.3%.

**Table ES.2** Trend of emissions and removals by sector (including LULUCF, Gg CO<sub>2</sub> eq)

	BY	1990	1995	2000	2005	2008	2009	2010	2011	2012
Energy	81,325	69,891	59,951	56,822	57,831	54,848	50,225	50,890	49,149	45,475
Industry	11,615	9,336	6,040	6,655	7,505	5,607	4,527	4,677	4,680	4,274
Solvent	290	246	256	220	390	421	367	307	349	350
Agriculture	18,588	15,159	9,106	9,452	9,132	9,069	8,539	8,498	8,730	8,705
LULUCF	-2,555	-1,967	-5,516	-609	-5,009	-4,686	-3,847	-3,939	-3,642	-4,407
Waste	2,630	2,970	3,122	3,355	3,518	3,383	3,318	3,265	3,126	3,176
<b>Total</b>	<b>111,892</b>	<b>95,636</b>	<b>72,958</b>	<b>75,895</b>	<b>73,367</b>	<b>68,642</b>	<b>63,129</b>	<b>63,699</b>	<b>62,392</b>	<b>57,574</b>

Base year=average of 1985-87

In 2012, **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: 87.4 per cent of total N<sub>2</sub>O emissions were generated in agriculture in 2012. Emissions from agriculture have decreased by 53.2% over the period of 1985-2012. The bulk of this reduction occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decline. The contribution of agriculture to total emissions decreased over the period 1985-2012 from 16.2% to its present share of 14.0%. Between 1996 and 2008, agricultural emissions had stagnated around 9.4 Mt with fluctuations up to 4%. 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 emission reduction. In 2009, swine population reduced by 11 per cent resulting in lower CH<sub>4</sub> and N<sub>2</sub>O emissions levels. 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 lower harvested production, thus lower emissions from crop residues. Agricultural emissions in 2010 were the lowest in the whole time-series. Emissions slightly increased in 2011, due to the higher N-fertilizer use, and

higher emissions from crop residues resulting from greater crop production. In 2012 emissions remained almost unchanged compared to the previous year, because the slightly higher emissions as a result of the increasing fertilizer use and cattle livestock population were nearly compensated by the effects of decreasing swine and poultry livestock number and lower amount of harvested crops.

The **industrial processes** sector was the third largest sector, contributing 6.9% to total GHG emissions in 2012. (Solvent and other product use added further 0.6% to total emissions.) The most important greenhouse gas was CO<sub>2</sub>, contributing 71.4% to total sectoral GHG emissions, followed by F-gases with 27.2%. Several recalculations within industry sector have influenced the changes of contribution of the subsectors compared to submission of last year. In 2012, 30.0% of the emissions came from mineral products, followed by 27.2% from consumption of halocarbons and SF<sub>6</sub> and 25.1% from non energy use of fuels. The contribution of chemical industry and iron and steel industry is 12.6% and 5.2% respectively. Process related industrial emissions decreased by 63.2% between base year and 2012, and by 43.1% between 2005 and 2012.

Although emissions of F-gases represent only 1.9% 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 steeply increased until 2008.

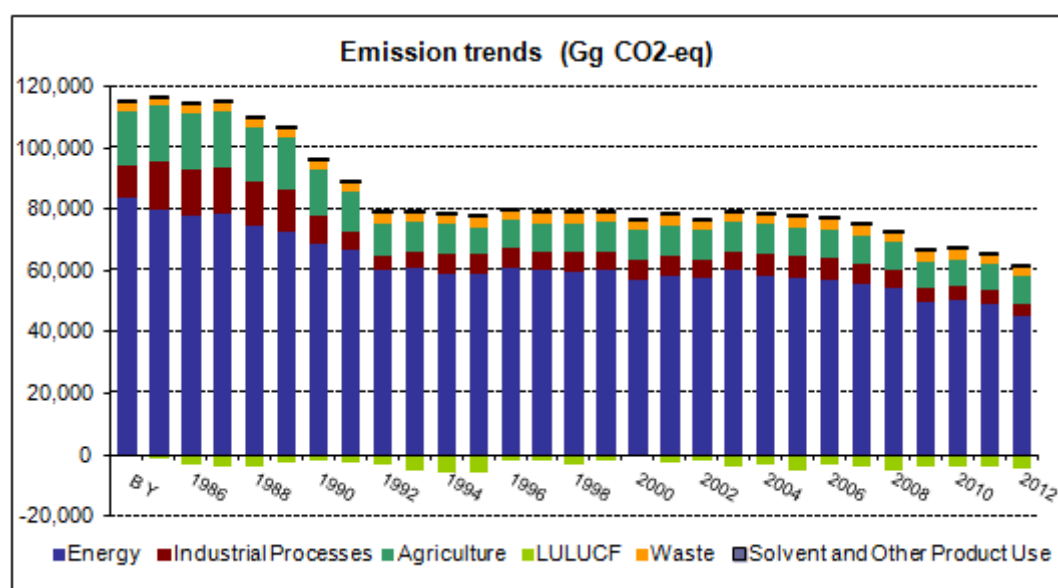
The trend in GHG emissions from industrial processes sector is still decreasing, as emission fell again by 8.7% (406.3 Gg) between 2011 and 2012. There is a 4.7% increase in mineral industry, following the significant recession of recent years. Emissions are by 10.1% lower in chemical industry, by 15% in consumption of halocarbons and SF<sub>6</sub>, by 34.5% in iron and steel industry and by 7.0% in Non energy use of fuels.

The **waste** sector represented 5.1% of total national GHG emissions in 2012. The largest category was solid waste disposal on land, representing 77.8% in 2012, followed by wastewater handling (18.1%), waste incineration (3.1%), and composting (1.0%). In contrast with other sectors, emissions from the waste sector are by 20.8% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 9.7% could be observed between 2005 and 2012. The degradation process in solid waste disposal sites is quite slow which means that waste that were disposed many years earlier have still an influence on current emission levels. However, the amount of disposed waste had decreased so significantly since 2005 (-33.9%), that methane emissions started to decrease as well. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

The **Land Use Land-Use Change and Forestry** 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 3.2 million tonnes removal, CO<sub>2</sub>-eq. net removals range from 0.7 million tonnes in 2000 to 5.6 million tonnes CO<sub>2</sub> in 1995. In 2012 the LULUCF sector accounted for 4.4 million tonnes carbon-dioxide removals. The net removals of forests amounted to 3.8 million tonnes CO<sub>2</sub>

Mineral soils in croplands remove a small amount of carbon (0.9 Mt in 2012), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favorable processes that increase the soil carbon content.

As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.1 million tonnes CO<sub>2</sub>-eq. mainly due to afforestation and reforestation in 2012. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 2.4 million tonnes CO<sub>2</sub>-eq.

**Figure ES.1** Change in greenhouse gas emissions from base year (1985-2012)

## 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 work to reach consistency with CLRTAP reporting of these gases is under development and it is highly improved in 2014 submission.

The following table shows the main trends in emissions:

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

	1990	2000	2003	2005	2006	2008	2009	2010	2011	2012
NO <sub>x</sub> , Gg	232.88	188.58	191.09	153.94	155.89	147.67	141.97	139.67	124.76	109.41
CO, Gg	1237.38	691.50	707.46	482.71	502.78	418.35	431.10	426.84	417.76	387.85
NMVOC, Gg	248.88	154.15	155.70	123.85	122.61	108.80	109.68	108.33	103.99	103.56
SO <sub>2</sub> , Gg	827.30	422.68	247.98	42.84	40.76	36.57	30.82	32.31	35.29	31.80

The database is not complete for the 80's.

The substantial reduction in sulphur dioxide emissions 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

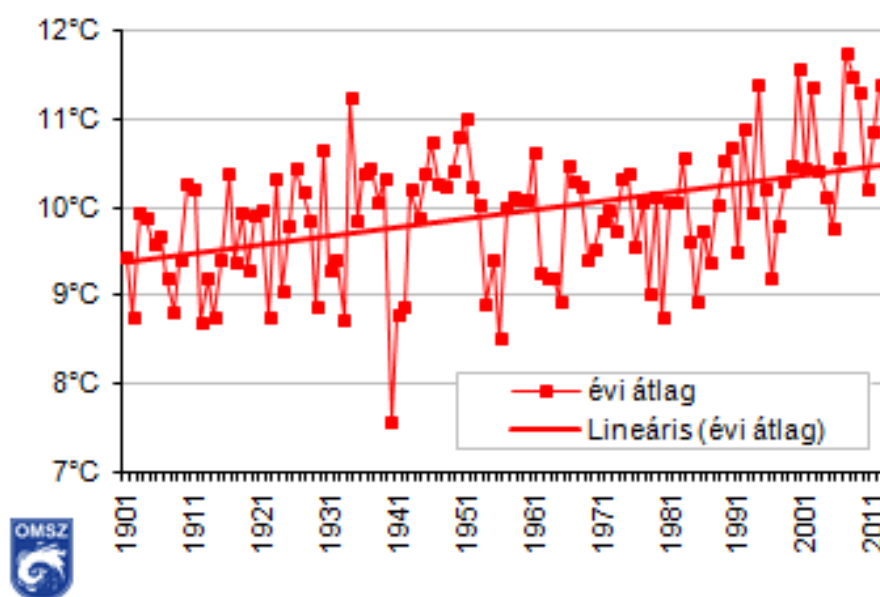
Hungary submitted the First National Communication in 1994 when the country joined the UN Framework Convention on Climate Change (hereinafter referred to as the Convention). In conjunction with this, the greenhouse gas inventories of the preceding years were prepared. Since then, inventories have been compiled annually as required. According to the Convention, year 1990 considered as the general reference level was not adequate for Hungary as a base year because the economic output of the country 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 was particularly important for HFCs because such gases had been used increasingly as replacements for ozone depleting chlorofluorocarbons since the early 1990's.). Hungary has chosen 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.

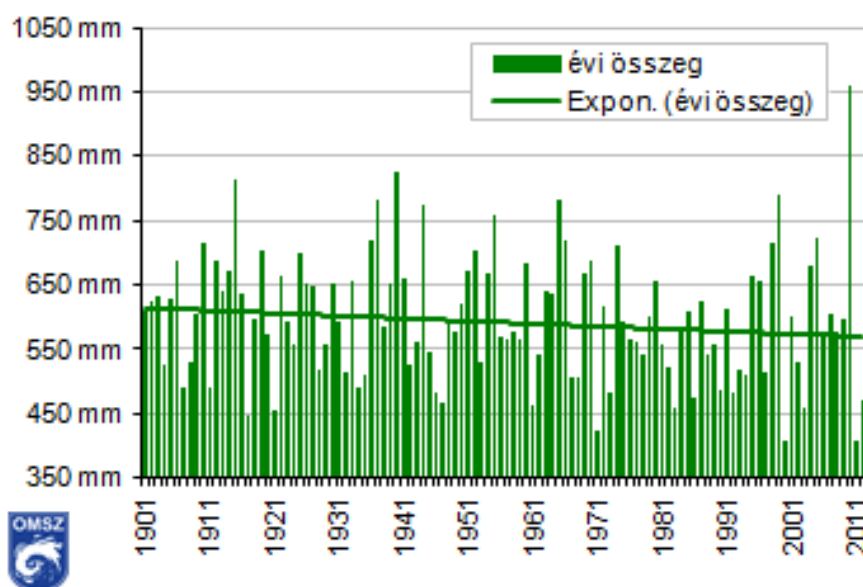
The regional effects of the global climate change can clearly be seen on the Hungarian observations. The annual averages of temperature in Hungary are very similar to the well-known wave of the global temperature since the beginning of the 20th century.



**Figure 1.1** Linear trends in annual mean temperature (°C) over the period 1901-2012 in Hungary

The yearly average temperature was 11.4°C in 2012 in Hungary. We had only 3 warmer years since 1901, and all of them were in the last decade. This fact only would suggest a warming process which can be confirmed by a linear trend that shows a temperature increase of 1.08°C for the last 112 years. Considering the last 30 years, the temperature increase is even more pronounced with +1.35°C based on the homogenized, interpolated dataset of the Hungarian Meteorological Service (*Fig. 1.1*).

The yearly total precipitation in 2012 (470.4 mm) was the tenth lowest ever recorded since 1901. The exponential trend fitted to the 112 year-long data series shows a moderate decline by 7 per cent, whereas for the last 32 years a growth of 10% can be seen (*Fig. 1.2*), although neither of these trends are significant.



**Figure 1.2** Exponential trends in annual precipitation sum (mm) over the period 1901-2012 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 basis and supervises the maintenance of the system.

At the very end of 2009, a new government decree 345/2009 (XII.30.) 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 National Food Chain Safety Office (NFCS, Forestry Directorate, formerly known as Central Agricultural Office) together with the National Agricultural Research and Innovation Centre (hereafter referred to as NARIC) Forest Research Institute is 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 making recommendations to HMS of the content of the inventory. The govt. decree had to be revised according to the changing EU regulations and reporting needs. Therefore Govt. Decree 345/2009 (XII.30) is now replaced by Govt. Decree 528/2013 (XII.30.).

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 the compilation of CRF tables and NIR. Within the team the experts are responsible for different sectors. Besides, a QA/QC coordinator and an archive manager have been 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 Forestry Directorate of the National Food Chain Safety Office and the NARIC Forest Research Institute as laid down by the above mentioned government decree. For the calculation of emissions from agricultural soils the Karcag Research Institute of University of Debrecen (Department of Soil Utilization and Rural Development) was contracted like in the last three years. Szent István University, Gödöllő had been heavily involved in the calculations for the agriculture sector of the inventory for several years. The following table summarizes the institutional arrangements:

<i>Function</i>	<i>Institution</i>	<i>Responsibilities</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> </ul>

<i>Function</i>	<i>Institution</i>	<i>Responsibilities</i>
		<ul style="list-style-type: none"> <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.	National Food Chain Safety Office (NFCSSO, Forestry Directorate)	<ul style="list-style-type: none"> <li>• Data collection, choice of methods and EFs, inventory preparation</li> </ul>
(by law)	NARIC Forest Research Institute	
Contribution to the inventory preparation of Agriculture sector	Szent István University, Gödöllő	<ul style="list-style-type: none"> <li>• Data collection, choice of method, development of country specific emission factors</li> <li>• Background studies</li> </ul>
Agricultural soils	Karcag Research Institute of University of Debrecen	<ul style="list-style-type: none"> <li>• Data collection, choice of methods and EFs, background research and studies</li> </ul>

### 1.3 Inventory preparation

The annual inventory cycle is carried out in accordance with the principles and procedures set out in the Revised IPCC 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 in consultation with the head of GHG Inventory Division. 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. QA/QC activities are described in more detail in chapter 1.7 and the full, updated QA/QC Plan (synthesizing the former QA/QC Plan, the old ISO Procedure and the old archiving manual) is included in Annex 6.

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	
From September to December (and April)	Calculations from external expert	
From September to December (and April)	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
15 April	Official submission	UNFCCC
31 July	Preliminary inventory of year x-1	EU
From 15 <sup>th</sup> of April to October	Archiving, QA/QC and Development Plan	internal

A Figure presenting the inventory cycle is included in Annex 6.

To summarizing the above, the two main compiler institutes are: (1) Hungarian Meteorological Service (HMS) and (2) Forestry Directorate of the National Food Chain Safety Office, the latter is responsible for the forestry part of the inventory.

The Meteorological Service, where an inventory team is located, is authorized by law to collect the necessary data. Calculations are either carried out by the GHG Division of the HMS 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 is collected 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 in addition to the data arriving based on the reporting obligation set up by Govt. Decree 528/2013 (XII.30) as described below in more detail). 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), the Energy Statistical Yearbook published earlier by the Energy Efficiency, Environment and Energy Information Agency, and the IEA/Eurostat Annual Questionnaires received directly from the domestic data provider, i.e. the Hungarian Energy and Public Utility Regulatory Authority. 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 and Nature. In addition to statistical data, contacts were established with the representatives of a number of major emitting sectors. Moreover, information from the web sites of international associations (e.g., International Iron and Steel Institute, IISI) is used as well. For the calculation of fluoride gas emissions, import data from the Customs Office and Police were used together with data obtained directly from companies importing and using fluorinated gases and information from cooling industry associations, the Hungarian Monitoring and Certification Body (OMKT-HMBC), the Hungarian Electrotechnical Association (MEE) and the National Directorate General for Disaster Management, Ministry of the Interior (NDGDM). 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 528/2013 (XII.30) on data provision relating to GHG emissions prescribes compulsory data provision for GHG inventory purposes for numerous governmental bodies and emitters. QA/QC Activities connected to data collection are regulated by the updated QA/QC Plan included in Annex 6.

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 GHG Division of the HMS 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 important information has been transferred to the HMS. The following information is stored elsewhere:

- Data from individual industrial plants – Ministry of Rural Development
- ETS data, registry - National Inspectorate for Environment and Nature
- Forestry statistics – National Food Chain Safety Office Forestry Directorate
- Wastewater data – National Inspectorate for Environment and Nature + 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 Management System of HMS.

As HMS is a central office, strict record management, documentation and archiving rules apply in general. HMS's general record management, documentation and archiving regulation have 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.

A particular issue of this regulation is to ensure the integrity of the data handling in relation 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 HMS, 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 HMS, the nominated archive manager is responsible for the maintenance of the archiving system in close cooperation with the IT Department of the Service.

The most important elements of the previously planned procedural manual for management and maintenance of the archiving system (archiving manual) have been included formally into the general record management, documentation and archiving regulation of the HMS and the new QA/QC Plan of the GHG Division of the HMS. (Instead of the introduction of a new regulation the already existing regulations have been amended and supplemented with the issues of the draft manual.). So these two regulations define the QA/QC activities connected to data collection, processing, storage and the documentation and archiving activities of the GHG Division. 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

TIER1 key category analysis was performed on the, more disaggregated list of source categories introduced in 2013 April submission which makes possible the more specific identification of the categories, where the available resources should be concentrated. The list was set up giving more detailed insight into the most emitting sectors and taking into account country specific properties, and it is presented in NIR ANNEX 1 TableA1-1. The key category analysis has been performed both with lists including and excluding LULUCF sectors as it was required by the review of last year.

As the same Tier1 KCA was performed also last year, it is possible to identify changes between the recent years, however there are only few ones:

- In Level assessment N<sub>2</sub>O emissions from 4.D.2. *Agricultural Soils - Pasture, range and paddock manure* sector became key in year 2012, as it was very near to the limit last year too and emissions slightly increased. Sector 5.E.1 *Land converted to settlements* became key category as well after the recalculation of the sector. 5.C.2. *Land converted to Grassland* and 2.C.1. *Iron and Steel* was identified as key in 2011 but not anymore in 2012.

- In Trend assessment sectors *CO<sub>2</sub> from Limestone and dolomite use, CH<sub>4</sub> from Cattle Manure Management, N<sub>2</sub>O from Synthetic Fertilizers and CO<sub>2</sub> from Land converted to Grassland* and 2.C.1. *Iron and steel* are not identified as key in 2012 analysis but have given their place to sectors *CO<sub>2</sub> from Forest Land remaining Forest Land, N<sub>2</sub>O emissions from Animal Manure, and 5.E.2. Land converted to settlements..* All these categories have been and are still very near to the limit of 95% contribution to trend of total emissions.

Key category analysis using TIER2 methodology followed the practice of last year. For TIER2 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 or disaggregating some sectors. In this way the sectors assessed cover the total emissions (with LULUCF). The threshold of Key source categories in Tier 2 analysis is 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 assessments were made with both methodologies.

**Table1.1** Number of identified Key categories using different methodologies

	<b>TIER1</b> (without uncertainties, including LULUCF) Number of key category / number of categories	<b>TIER2</b> (with uncertainties, including LULUCF) Number of key category / number of categories
<b>LEVEL</b>	38/ 196	12 / 63
<b>TREND</b>	39/ 196	18 / 63

**Table1.2** Key category analysis summary

IPCC Source Categories			KC			
1A1a	Gas	Energy - Stationary Combustion - Public electricity and heat production	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A1a	Liquid	Energy - Stationary Combustion - Public electricity and heat production	CO <sub>2</sub>		T1	T1exL
1A1a	Other	Energy - Stationary Combustion - Public electricity and heat production	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A1a	Solid	Energy - Stationary Combustion - Public electricity and heat production	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A1b	Gas	Energy - Stationary Combustion - Petroleum refining	CO <sub>2</sub>	L1		L1exL
1A1b	Liquid	Energy - Stationary Combustion - Petroleum refining	CO <sub>2</sub>	L1		L1exL
1A2	Gas	Energy - Manufacturing Industries and Construction	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A2	Liquid	Energy - Manufacturing Industries and Construction	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A2	Solid	Energy - Manufacturing Industries and Construction	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A3b	Diesel	Energy - Mobile combustion - Road transportation	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A3b	Gasoline	Energy - Mobile combustion - Road transportation	CO <sub>2</sub>	L1	T1	L1exL T1exL
1A3c	Liquid	Energy - Mobile combustion - Other: Civil Aviation, Railways, Navigation	CO <sub>2</sub>		T1	T1exL
1A4	Biomass	Energy - Stationary Combustion - Other	CH <sub>4</sub>			L1exL

1A4	Gas	Energy - Stationary Combustion - Other	CO2	L1	T1	L1exL	T1exL
1A4	Liquid	Energy - Stationary Combustion - Other	CO2	L1	T1	L1exL	T1exL
1A4	Solid	Energy - Stationary Combustion - Other	CH4		T1		T1exL
1A4	Solid	Energy - Stationary Combustion - Other	CO2	L1	T1	L1exL	T1exL
1B1a		Energy - Fugitive Emissions from Fuels - Solid Fuels	CH4		T1		T1exL
1B2b		Energy - Fugitive Emissions from Fuels - Oil and Natural Gas	CH4	L1	T1	L1exL	T1exL
1B2d		Energy - Fugitive Emissions from Fuels - Oil and Natural Gas	CH4	L1	T1	L1exL	T1exL
2A1		Industrial Processes - Mineral Products - Cement production	CO2	L1	T1	L1exL	T1exL
2A2		Industrial Processes - Mineral Products - Lime production	CO2		T1		T1exL
2A3		Industrial Processes - Mineral Products - Limestone and dolomit use	CO2	L1		L1exL	T1exL
2A7		Industrial Processes - Mineral Products - Other	CO2		T1		T1exL
2B1		Industrial Processes - Chemical Industry - Ammonia production	CO2	L1	T1	L1exL	T1exL
2B2		Industrial Processes - Chemical Industry - Nitric acid production	N2O		T1		T1exL
2Fa1		Industrial Processes - Consumption of Halocarbons and SF6 - Refrigeration and air conditioning equipment	HFCs	L1	T1	L1exL	T1exL
2G1		Industrial Processes - Feedstocks	CO2	L1	T1	L1exL	T1exL
3d		Solvent and Other Product Use - Other	N2O	L1	T1	L1exL	T1exL
4A1		Agriculture - Enteric Fermentation /Cattle	CH4	L1	T1	L1exL	T1exL
4B13	Solid	Agriculture - Manure Management /Solid	N2O	L1	T1	L1exL	T1exL
4B1	Cattle	Agriculture - Manure Management /Cattle	CH4	L1		L1exL	
4B8	Swine	Agriculture - Manure Management /Swine	CH4	L1	T1	L1exL	T1exL
4D1.1.	0	Agriculture - Agricultural Soils - Direct soil emissions /Synthetic Fertilizer	N2O	L1		L1exL	
4D1.2-4.		Agriculture - Agricultural Soils - Direct soil emissions / Animal Manure and other	N2O	L1	T1	L1exL	
4D2		Agriculture - Agricultural Soils - Pasture, range and paddock manure	N2O	L1		L1exL	
4D3		Agriculture - Agricultural Soils - Indirect emissions	N2O	L1	T1	L1exL	
5A1		LULUCF - Forest Land - remaining	CO2	L1	T1		
5A2		LULUCF - Forest Land - converted to	CO2	L1	T1		
5B1		LULUCF - Cropland - remaining	CO2	L1	T1		
5B2		LULUCF - Cropland - converted to	CO2	L1	T1		
5C1		LULUCF - Grassland remaining Grassland	CO2	L1	T1		
5E2		LULUCF - Land converted to Settlements	CO2	L1	T1		
6A		Waste - Solid Waste Disposal on Land	CH4	L1	T1	L1exL	T1exL
6B2		Waste - Waste-water Handling - Domestic and Commercial	CH4	L1		L1exL	
6B2		Waste - Waste-water Handling - Domestic and Commercial	N2O	L1		L1exL	

Notation key:

L1= Level Assessment using TIER1 methodology, including LULUCF sectors

T1=Trend Assessment using TIER1 methodology, including LULUCF sectors

L1exL= Level Assessment using TIER1 methodology, excluding LULUCF sectors

T1exL=Trend Assessment using TIER1 methodology, excluding LULUCF sectors

IPCC Source Categories		GHG	Tier2 KCA	
1. A.	Stationary Combustion - Gas	CO2	L2	T2
1. A.	Stationary Combustion - Coal	CO2	L2	T2
1. A.	Stationary Combustion - Oil	CO2		T2
1. A. 3. B.	Mobile Combustion - Road	CO2	L2	T2
1. B. 2.	Fugitive Emissions from Oil and Gas Operations (Main Source: Gas Distribution)	CH4	L2	T2
2.	HFCs Emissions from Industry	HFCs		T2
2.	SF6 Emissions from Industry	SF6		T2
4. B.	N2O Emissions from Manure Management	N2O	L2	T2
4. D. 1.	Direct N2O Emissions from Agricultural Soils	N2O	L2	
4. D. 3.	Indirect N2O Emissions from Nitrogen Used in Agriculture	N2O	L2	T2
5.A.1	Forest Land remaining forest Land	CO2	L2	T2
5.A.2	Land converted to Forest Land	CO2		T2
5.B.	Cropland	N2O		T2
5.B.1	Cropland remaining Cropland	CO2	L2	T2
5.B.2	Land converted to Cropland	CO2		T2
5.C.1	Grassland remaining Grassland	CO2	L2	T2
5.C.2	Land converted to Grassland	CO2		T2
6. A.	CH4 Emissions from Solid Waste Disposal Sites	CH4	L2	T2
6. B.	Emissions from Wastewater Handling	N2O	L2	T2

Notation key:

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. The updated QA/QC Plan that entered into force in 2013 aims to integrate these two set of requirements.

### 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; registers and records for quality checks and documentation. Of course from that time general, HMS level QA/QC activities apply for the GHG Division as well, such as general quality objectives, application of QA/QC Manual of the HMS, QA/QC regarding contractors, etc. Further information on quality management system of the HMS is available in English at: <http://www.met.hu/en/omsz/minosegiranynitas/>

In 2012 the ISO procedure of the GHG division was reviewed, and the former QA/QC Plan with the archiving manual was integrated into it. So, from now on this new ISO document No.: ELFO\_UHG\_401 entered into force on 4<sup>th</sup> January 2013 and updated in 2014 can be regarded as the QA/QC Plan required for inventory preparation. In addition the records used for documentation of QA/QC and other standardized activities have also been renewed. The records and their functions are the following:

- UHG01: QA/QC checklist: to be filled in by sectoral experts which includes a compulsory check list, summary of results of checks, suggestions for corrective actions and planned improvements as suggested by Chapter 8 of GPG2000, Chapter 5.5 of GPG2003 for LULUCF and Annex 6A of the 2006 Guidelines;
- UHG02: Data quality check: to be filled in case of data providers and external experts on data quality;
- UHG03: Development Plan: to be filled in every year by the end of the inventory cycle based on the outcome of all reviews and own experience;
- UHG04: Responsibility: for the specification of the sectoral responsibilities of the core team and the QA/QC coordinator
- UHG05: Data source logbook: for the standardized documentation of data sources;
- UHG06: Uncertainty and UHG07: Key category analysis; for the standardized documentation of uncertainty and key category analysis.
- UHG08: Logbook of QA activities: for the documentation of any external input.

The records and the English translation of the QA/QC Plan are presented in Annex 6 of the NIR.

The QA/QC Plan contains detailed description of the data collection, inventory preparation and reporting processes, regulates the documentation and archiving activities in order to ensure transparency and reproducibility of the inventory the same as before, especially:

- ELFO\_UHG\_401 formalizes the data collection and inventory preparation procedure as it is described also in chapters 1.4 and 1.5 above. It is important to note that the authorization of HMS for collecting non public data has been raised in a legally binding level by since 2009 when 528/2013. (XII.30.) Govt. Decree entered into force. In addition Act LX of 2007 on the implementation framework of the UN Framework Convention on Climate Change and the Kyoto Protocol authorizes HMS to collect confidential data if needed as well. ELFO\_UHG\_401 prescribes that any data used by the preparation of the inventory have to be documented and archived.
- Documentation and archiving: As it is mentioned in chapter 1.4 above, the Hungarian Meteorological Service is a central office under the control of the Ministry of Rural Development. Strict documentation and archiving is a basic requirement by the institution. The HMS has a documentation and archiving manual valid for the whole institution, which defines that all the incoming letters and emails containing data have to be registered in the central registry system of HMS. This ensures that every document is traceable. In additional data, data sources and calculation files and background documents for every inventory submission need to be documented and archived by the sectoral experts. The exact process of documentation and archiving (naming and location) is detailed in document ELFO\_UHG\_401.
- 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. UHG02 QC record was created for standardized documentation of evaluation of data quality by the data providers which can be regarded as a continuous development. The QA/QC plan prescribes the obligation of filling in the records mentioned before, including Development Plan, where first of all the recommendations of the last years' reviews conducted by the expert review team of the UNFCCC have to be taken into consideration as much as possible every year.

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 and a comprehensive external audit was again performed in January 2014 as well. On the 5<sup>th</sup> April 2013 an internal audit has been performed too. In both cases the result was a few non significant recommendations.

Therefore we can claim that the GHG inventory is subject to and our procedures are in line with ISO 9001:2008.

As part of the QA and verification activities 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

In 2012 the EU carried out a comprehensive individual technical review concentrating on the years 2005, 2008, 2009 and 2010, which can be regarded as an additional QA activity.

Further QA and verification activities to be continuously performed and/or planned:

- Checking the results of the EU's internal review for the EU15, and analyze its relevance for Hungary.
- Checking the differences in activity data to increase the consistency between different emission databases, especially the GHG inventory, LRTAP inventory, ETS data, NAMEA data, and the E-PRTR data.
- Incorporation of ETS data in broader extent for revision of the used EFs and for better sectoral allocation of emissions.
- Comprehensive consistency checks between national energy statistics and IEA time series.
- R+D projects. The Hungarian Meteorological Service funds research and development projects for the improvement of the inventory whenever possible.
- Active participation in the support project organized by EU DG Climate for the „Assistance of Member States for effective implementation of the reporting requirements under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC)”
- Training plan.

### 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 Meteorological Service. These sectoral responsibilities are laid down in the QC record No.UHG04. 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. 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 and QC record UHG02 has been introduced for the documentation of evaluation of data quality by data providers. 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. The QA/QC Plan has been updated in 2014 in order to implement changes due to EU Monitoring Mechanism Regulation and recommendations of UNFCCC centralized review of the last year. Please find the updated version in Annex 6.

## 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 72.2 % in the total emission (in CO<sub>2</sub>-eq including LULUCF; 74.3% excluding LULUCF). The least reliable is N<sub>2</sub>O calculation representing 11.8% (in CO<sub>2</sub>-eq including LULUCF; 10.9% excluding LULUCF). CH<sub>4</sub>, which has a medium reliability, has a similar proportion (13.9% in CO<sub>2</sub>-eq including LULUCF; 12.9% excluding LULUCF). Fluorinated gases are irrelevant here because their contribution to the total emission is only 2.0% (in CO<sub>2</sub>-eq including LULUCF; 1.9% excluding 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>	6.2% (3.5% excluding LULUCF)
CH <sub>4</sub>	16.5% (16.6% excluding LULUCF)
N <sub>2</sub> O	196.9% (198.1% excluding LULUCF)

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 2012) is 23.8% (21.9% excluding LULUCF) and the uncertainty introduced in trend in national emissions is 2.8% (2.0% excluding LULUCF).

Please find further details regarding the calculation of uncertainties in Annex 7 of the NIR.

## 1.9 Completeness

GHG inventory data are provided for the base year (the average of the three years 1985–1987) and the years 1985–2012. 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

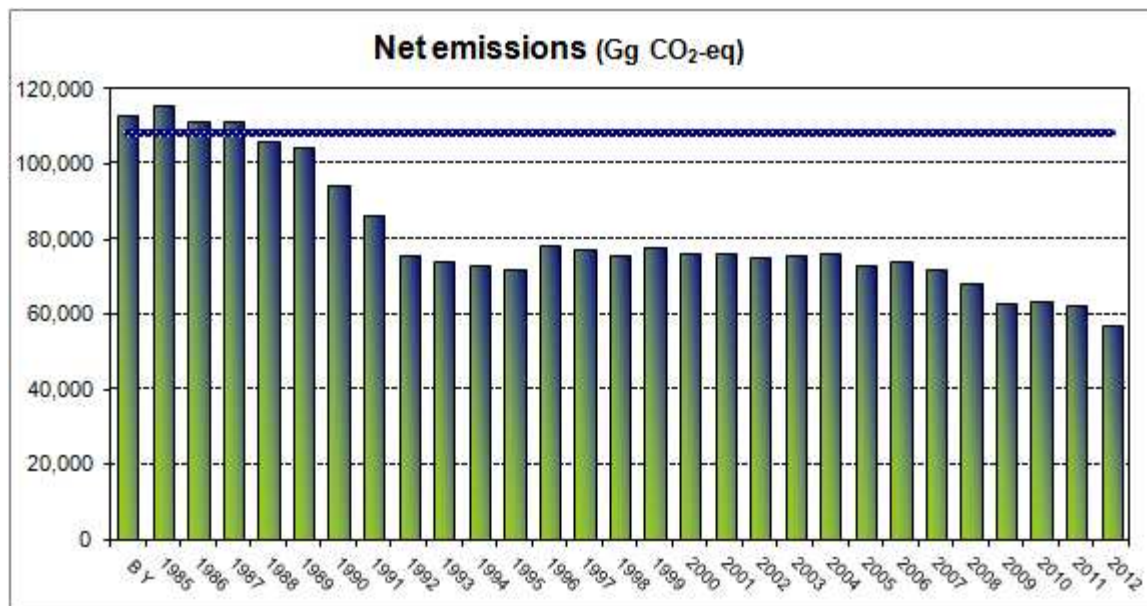
The trends of the total greenhouse gas emissions may be assessed on the basis of the GWP. The table below shows the time series of net and gross emissions:

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

	BY fixed	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total (incl.LULUCF)	112,661	95,636	72,958	75,895	73,367	68,642	63,129	63,699	62,392	57,574
Total (excl.LULUCF)	115,397	97,603	78,475	76,504	78,376	73,328	66,976	67,638	66,034	61,981

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.

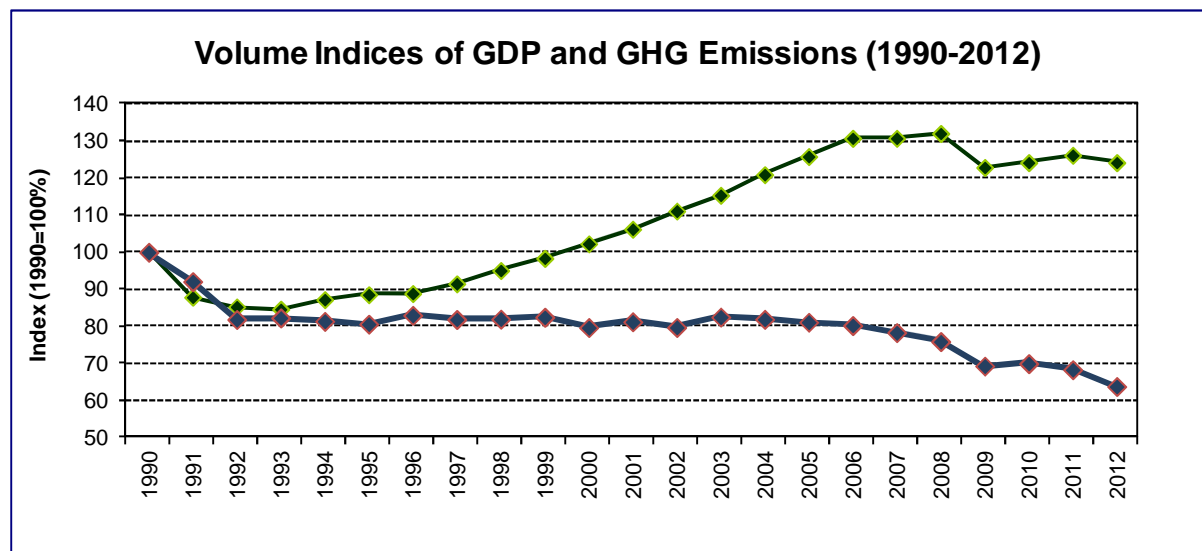


**Figure 2.1** Total emission (including net CO<sub>2</sub> from LULUCF) between 1985 and 2012

Compared to the base year, emissions were significantly reduced in the energy (-44.1%), agriculture (-53.2%) and industrial processes (-63.2%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+20.8%). Solvent and other product use and land use, land-use change and forestry (LULUCF) sectors show fluctuating behavior.

For a better understanding of 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 (1995-2005) 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 were decreasing.



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

In the third period, after 2005, Hungary experienced an emission reduction of 20.9%, out of which 6.4% occurred 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. From 2010 on a slight recovery of the economy could be observed, the emissions, however, remained at a relatively low level.

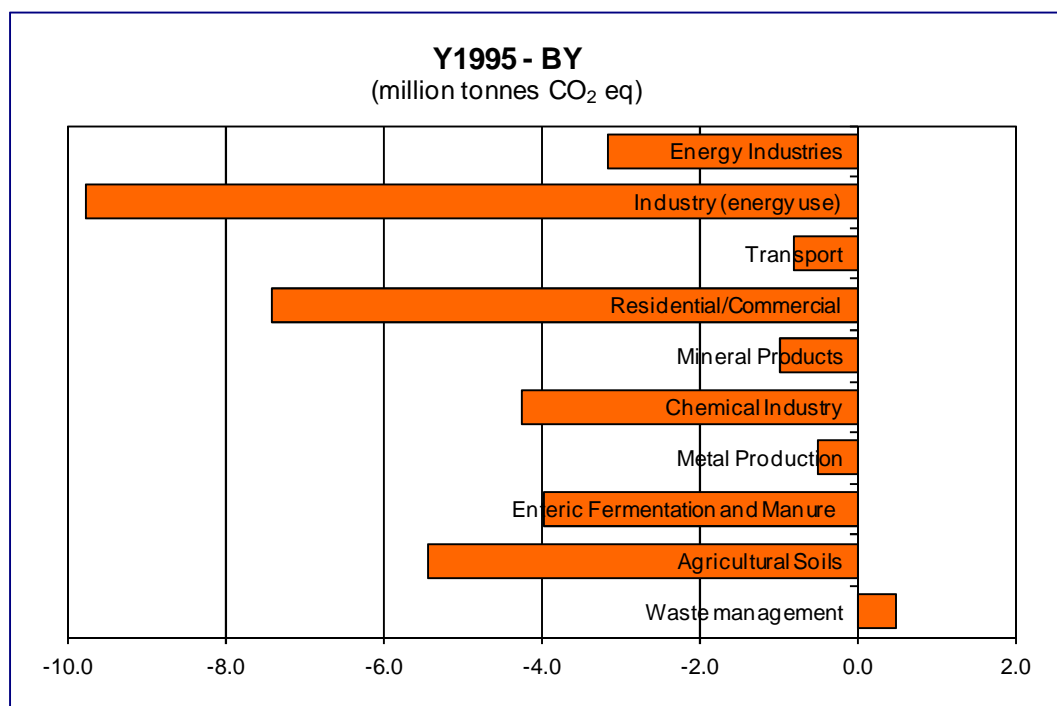
Starting with the first period, the process of transition into market economy brought in its train radical and painful decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors (energy, industry and agriculture). Consequently, 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 a result of the political and economic processes, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30%, the livestock by about 50%, and the use of fertilizers by more than 60%. As a

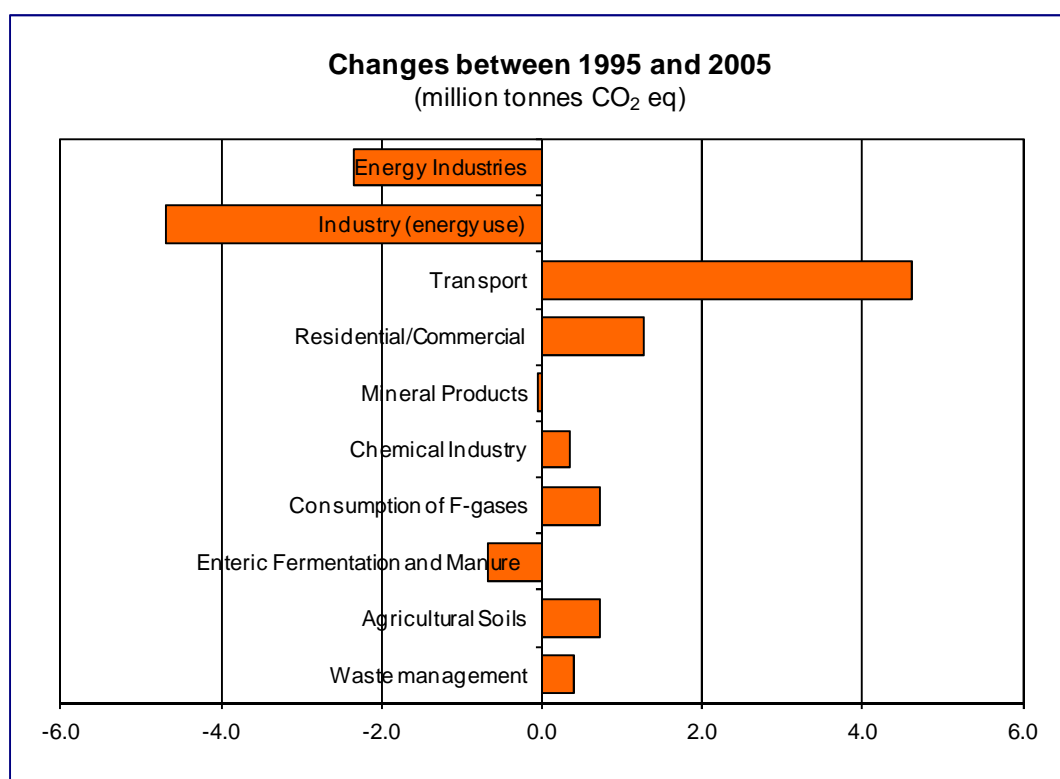
consequence, the share of the agricultural sector in total GHG emissions decreased from 16.2% to 11.6%.



**Figure 2.3** Changes in emissions due to regime change (1985-95)

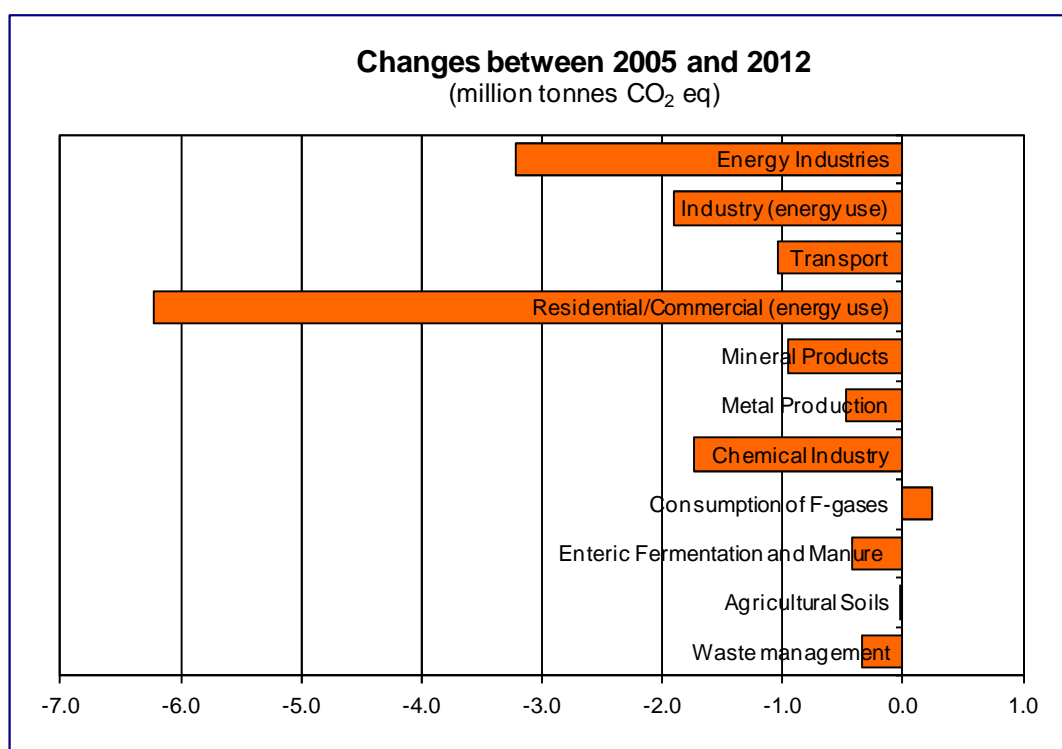
The small increase of emissions in the *Waste* sector is exceptional among all the sectors, and it is attributable to the slightly increasing quantities of waste generated and collected but more importantly to the applied calculation method which assumes that the degradable organic component in waste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

After the mid 90's, emissions seemed to have stabilized around 79 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 less than 10% share in CO<sub>2</sub> emissions. In contrast, emissions from transport increased significantly by almost 5 million tonnes CO<sub>2</sub> equivalent which represented a growth of 63.6%.



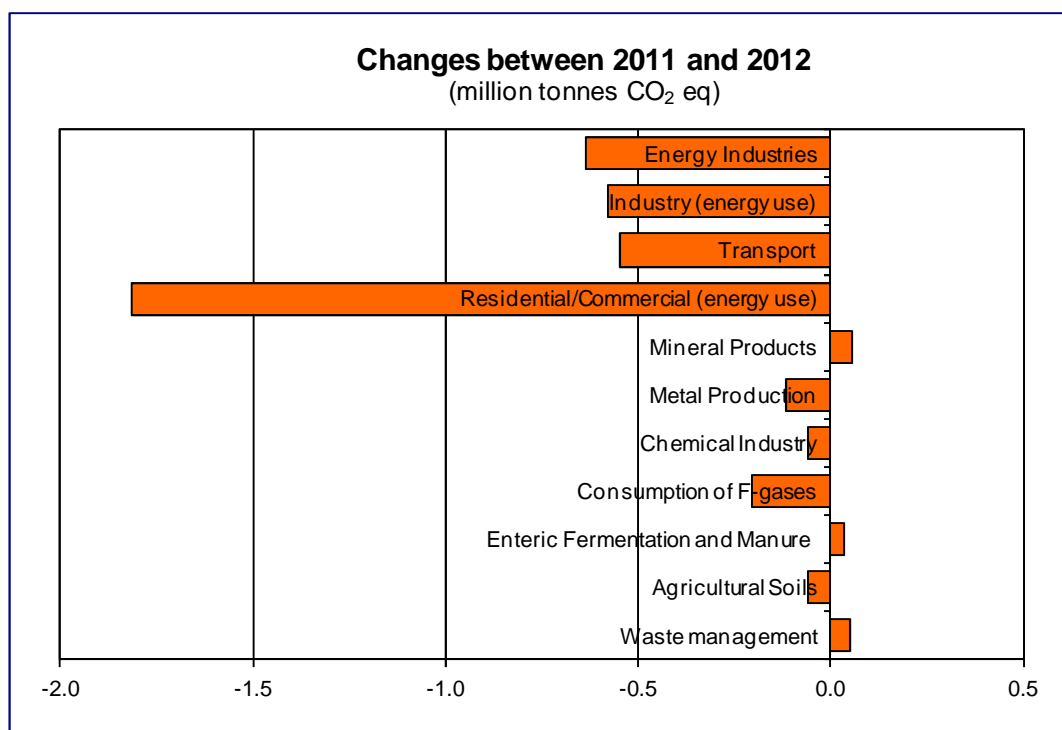
**Figure 2.4** Changes in emissions between 1995 and 2005

In the third period, after 2005, emissions fell by 16.4 million tonnes or 20.9%. About one third 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% (most importantly including a 18% 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 8.7% (-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 (-19.3%) occurred in the industrial processes sector mainly due to lower production volumes especially in mineral product manufacturing (-28.8%). Parallel to that, also energy use decreased in manufacturing industries and construction, consequently GHG emission fell by 21.9% here. Regarding absolute changes in emissions, out of the 6.4 million tonnes reduction, fuel combustion was responsible for about 4.7 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 2012

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. The change in GHG emissions was less pronounced: it increased still by 1.0% above the 2009 level.



**Figure 2.6** Changes in emissions between 2011 and 2012

And then in 2011, we can see decreases in many areas but especially in the energy sector. Electricity production decreased by 3.9% which resulted in a similar fall in GHG emissions. Natural gas consumption of the residential sector dropped by 9.0%. Transport emissions fell

by 2.8%, mineral production by a further 12.7%. Chemical industry and agricultural soils are the two main exceptions. In agriculture we had higher fertilizer use, and greater crop production (hence higher emissions from crop residues). In this respect, it is worth noting that the economic growth in 2011 was mainly driven by agricultural production.

In 2012, the decreasing trend in emissions continued and we have reached the lowest emission level ever. The decrease of 4.1 million tonnes (or -6.1%) can almost be explained by processes in the energy sector alone (e.g. further decrease in electricity production, a 13.5% drop in natural gas consumption in "other sectors") as it will be elaborated more in chapter 2.3.

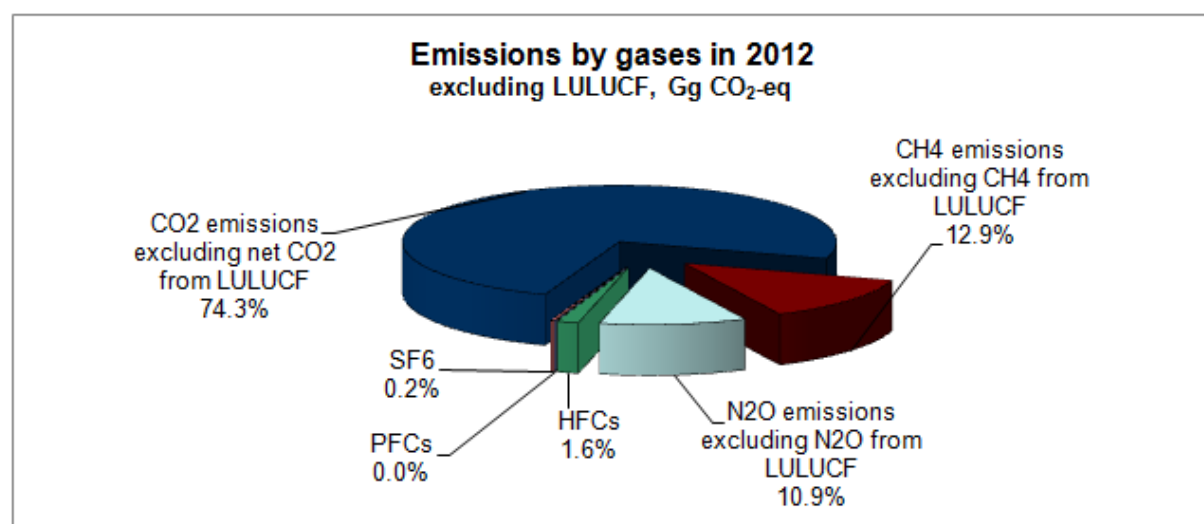
## 2.2 Description and interpretation of emission trends by gas

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  
(excluding LULUCF Gg CO<sub>2</sub> eq)

	BY	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO <sub>2</sub>	84,378	72,475	61,330	58,081	59,946	56,700	51,029	51,668	49,859	46,072
CH <sub>4</sub>	12,638	11,876	9,262	9,314	8,620	8,286	8,164	8,156	7,986	7,990
N <sub>2</sub> O	17,089	12,893	7,508	8,466	8,680	7,077	6,615	6,540	6,824	6,757
HFCs	0	0	38	237	682	986	944	1,039	1,145	1,006
PFCs	268	271	167	212	210	4	3	1	2	1
SF <sub>6</sub>	73	88	170	195	238	276	221	235	220	153
<b>Total</b>	<b>114,447</b>	<b>97,603</b>	<b>78,475</b>	<b>76,504</b>	<b>78,376</b>	<b>73,328</b>	<b>66,976</b>	<b>67,638</b>	<b>66,034</b>	<b>61,981</b>

Base year=average of 1985-87

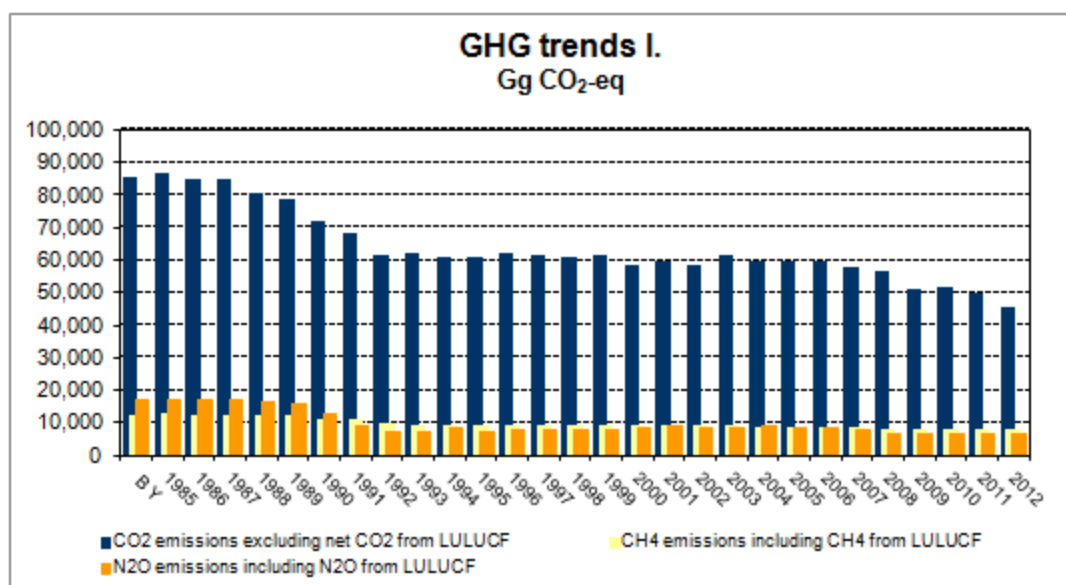


**Figure 2.7** Shares of emissions of greenhouse gases in 2012

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 decline of the national output. 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. After 2005, CO<sub>2</sub> emissions decreased by 23.1 per cent which is almost comparable with the decrease during the regime change around 1990.

The drop of emission accelerated after 2008 mainly driven by the global economic crisis. 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 until 2005, but started to decrease recently. This is the reason why the resultant trend was relatively stagnating until the first half of the last decade, and why it has been slowly decreasing since then.

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.

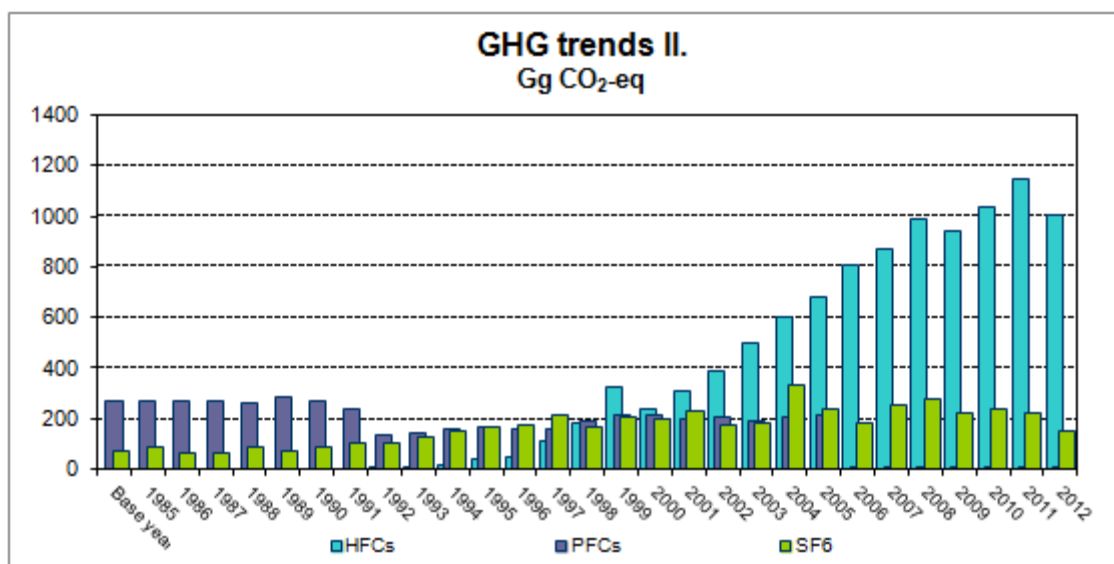


**Figure 2.8** Trend of emissions by gases  
 Note: BY=average of 1985-87 but 1995 for F-gases

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 their steadily growing tendency seems to level off since 2008.

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.

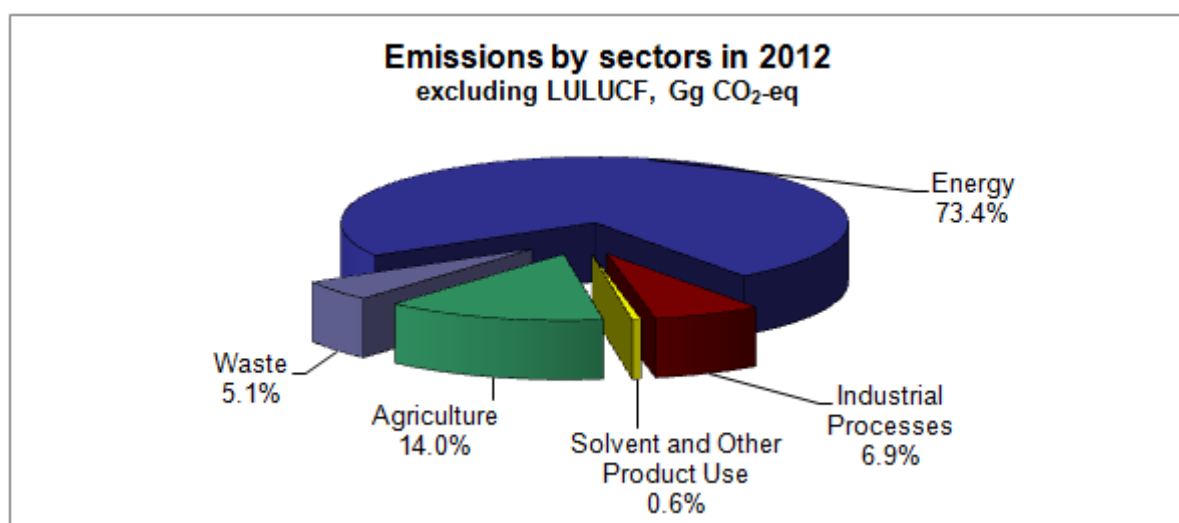
SF<sub>6</sub> emissions primarily depend on the uses in electricity transmission, as it is mainly used in electrical equipments, first of all in switchgears for insulation and arc quenching. So, the growth of the electricity consumption results in an increasing application of SF<sub>6</sub>, however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



**Figure 2.9 F-gases trend (1985-2012)**  
 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 73.4% to the total GHG emission in 2012. Agriculture was the second largest sector with 14.0% while emissions from industrial processes (with solvent and other product use) accounted for 7.5% and the waste sector contributed 5.1%. Compared to the base year, emissions were significantly reduced in the energy (-44.1%), agriculture (-53.2%), and industrial processes (-63.2%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+20.8%). 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 2012**

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 reductions in the residential sector and manufacturing

industries. And then the economic crisis came...

The energy sector was responsible for 73.4% of total GHG emissions in 2012. Carbon dioxide from fossil fuels was the largest item among greenhouse gas emissions contributing 94.2% to the sectoral emission. Considering fuel use in combustion processes, gases had the highest proportion (48.9%), liquids and solids represented 26.6% and 14.2%, respectively. It is worth mentioning that the share of biomass in fuel combustion grew to 9.5%. The most important subsector was energy industries with a proportion of 36.4% within the energy sector, followed by other sectors (26.1%) and transport (23.9%). Fugitive emissions from fuels played only a small role with 4.9% out of which 71.1% originate from natural gas production, processing, transmission and distribution. While the fugitive emissions connected to natural gas operations show an increasing tendency (46.1% 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 99.9% smaller than the base year caused by the huge recession of underground coal mining in Hungary. The aggregate change of sector 1B – Fugitive emissions is 23.4% 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 have decreased by 7.5% or 3.7 million tonnes between 2011 and 2012. The biggest change occurred in the "other sectors" (-13.2% or -1.8 million tonnes) mainly because natural gas consumption dropped by 13.5%. Commercial and public services purchased by a fifth less natural gas than in previous year, and we have not seen such a low consumption in the residential sector since the early 90's. Gross electricity production fell back by a further 3.9% (after a drop of 3.7% in 2011). Moreover, the decrease in natural gas based electricity production was the most pronounced (-12%), whereas the share of CO<sub>2</sub> neutral nuclear fuel has steadily grown in the last few years, and wind energy utilization showed a steep increase. In addition, electricity import grew significantly by 16% in 2012. Emissions from transport continued to decrease (-4.8%). Transport related emissions almost doubled between 1994 and 2007, since then, however, a decrease of 17.1% could be observed. Motor gasoline use has never been lower since 1990 than in 2011-2012, and road diesel consumption fell back as well by almost 8%. In addition, energy consumption of manufacturing industries decreased by 16.3%.

In 2012, **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. More than 85 percent of total N<sub>2</sub>O emissions were generated in agriculture in 2012. Emissions from agriculture have decreased by 53.2% over the period of 1985-2012. The bulk of this reduction occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 percent, and livestock numbers underwent a drastic decline. The contribution of agriculture to total emissions decreased over the period 1985-2012 from 16.2% to its present share of 14.0%.

Between 1996 and 2008, agricultural emissions had stagnated around 9.4 Mt with fluctuations up to 4%. 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 was 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 and in 2010 the cattle population fell by 5 per cent, resulting in 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.

Agricultural emissions slightly increased in 2011, due to the higher N-fertilizer use, and higher emissions from crop residues resulting from greater crop production.

There was also a slight decrease in the volume of the agricultural production in 2012, as a result of the extremely dry weather. In spite of that emissions remained almost unchanged compared to previous year, because the slightly higher emissions due to the increase in fertilizer use and cattle livestock population were nearly compensated by the effects of decreasing swine and poultry livestock number and lower amount of harvested crops.

The **industrial processes** sector was the third largest sector, contributing 6.9% to total GHG emissions in 2012. (Solvent and other product use added further 0.6% to total emissions.) The most important greenhouse gas was CO<sub>2</sub>, contributing 71.4% to total sectoral GHG emissions, followed by F-gases with 27.2%. Several recalculations within industry sector have influenced the changes of contribution of the subsectors compared to submission of last year. In 2012, 30.0% of the emissions came from mineral products, followed by 27.2% from consumption of halocarbons and SF<sub>6</sub> and 25.1% from non energy use of fuels. The contribution of chemical industry and iron and steel industry is 12.6% and 5.2% respectively. Process related industrial emissions decreased by 63.2% between base year and 2012, and by 43.1% between 2005 and 2012.

Although emissions of F-gases represent only 1.9% 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 steeply increased until 2008.

The trend in GHG emissions from industrial processes sector is still decreasing, as emissions fall again by 8.7% (406.3 Gg) between 2011 and 2012. There is a 4.7% increase in mineral industry, following the significant recession of recent years. Emissions are lower by 10.1% in chemical industry, by 15% in consumption of halocarbons and SF<sub>6</sub>, by 34.5% in iron and steel industry and by 7.0% in Non-energy use of fuels.

The **waste** sector represented 5.1% of total national GHG emissions in 2012. The largest category was solid waste disposal on land, representing 77.8% in 2012, followed by wastewater handling (18.1%), waste incineration (3.1%), and composting (1.0%). In contrast with other sectors, emissions from the waste sector are by 20.8% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 9.7% could be observed between 2005 and 2012. The degradation process in solid waste disposal sites is quite slow which means that waste that were disposed many years earlier have still an influence on current emission levels. However, the amount of disposed waste had decreased so significantly since 2005 (-33.9%), that methane emissions started to decrease as well. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

The **Land Use Land-Use Change and Forestry** 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 3.2 million tonnes removal, CO<sub>2</sub>-eq. net removals range from 0.7 million tonnes in 1985 to 5.6 million tonnes CO<sub>2</sub> in 1995. In 2012 the LULUCF sector accounted for 4.4million tonnes carbon-dioxide removals. The removals of forests amounted to 3.8 million tonnes.

Mineral soils in Cropland remove a small amount of carbon (0.9 Mt in 2012), as the abandonment of croplands and the replacement of conventional tillage method by new soil conservation tillage methods represent favorable processes that increase the soil carbon content.

As regards KP-LULUCF, the activities under Article 3.3 represented a net sink of 1.1 million tonnes CO<sub>2</sub>-eq. mainly due to afforestation and reforestation in 2012. Similarly, the activity under Article 3.4, i.e. forest management, was also a net sink of 2.4 million tonnes CO<sub>2</sub>-eq.

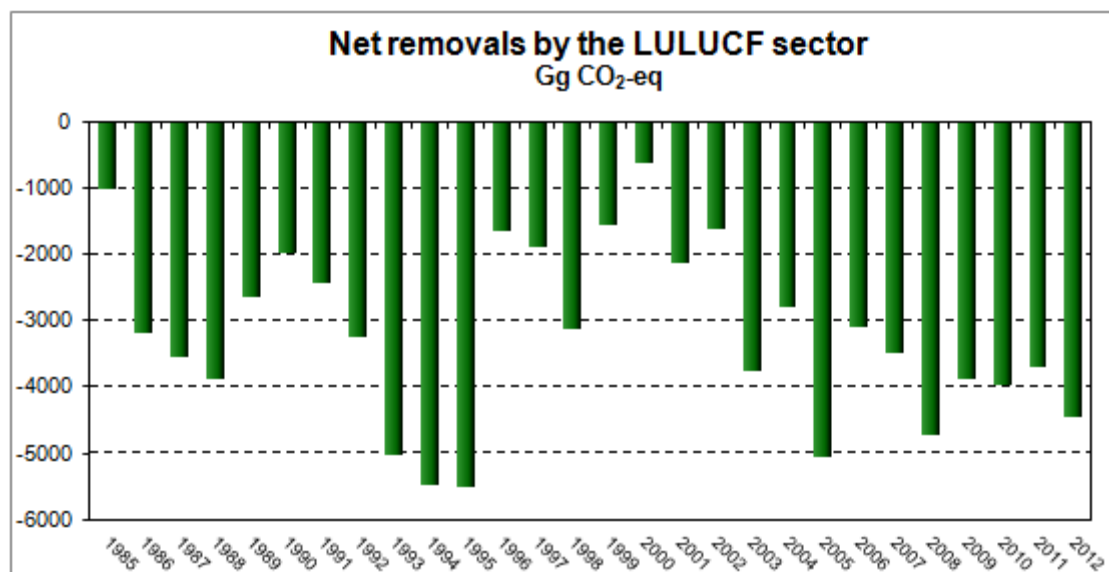


Figure 2.11 Sinks of LULUCF

## 2.4 Trends of indirect 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 work to reach consistency with CLRTAP reporting of these gases is under progress but it is highly improved in 2014 submission.

The following table shows the main trends in emissions:

**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.

	1990	2000	2003	2005	2006	2008	2009	2010	2011	2012
NO <sub>x</sub> , Gg	232.88	188.58	191.09	153.94	155.89	147.67	141.97	139.67	124.76	109.41
CO, Gg	1237.38	691.50	707.46	482.71	502.78	418.35	431.10	426.84	417.76	387.85
NMVOC, Gg	248.88	154.15	155.70	123.85	122.61	108.80	109.68	108.33	103.99	103.56
SO <sub>2</sub> , Gg	827.30	422.68	247.98	42.84	40.76	36.57	30.82	32.31	35.29	31.80

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)

#### Recent key developments:

- Since 2005, Hungary has experienced an almost constant emission reduction in the energy sector. Current GHG emissions are by 21.4 per cent lower than in 2005;
- Emissions from the energy sector have decreased by 7.5% or 3.7 million tonnes between 2011 and 2012. The biggest change occurred in the “other sectors” (-13.2% or -1.8 million tonnes) mainly because natural gas consumption dropped significantly;
- Commercial and public services purchased by a fifth less natural gas than in previous year, and we have not seen such a low consumption in the residential sector since the early 90's;
- Gross electricity production fell back by a further 3.9% after a drop of 3.7% in 2011. The decrease in natural gas based electricity production was the most pronounced (-12%). In addition, electricity import grew significantly by 16% in 2012;
- Emissions from transport continued to decrease (-4.8%). Transport related emissions almost doubled between 1994 and 2007, since then a decrease of 17.1% could be observed. Motor gasoline use has never been lower since 1985 than in 2011-2012.
- Energy consumption of manufacturing industries decreased by 16.3% and reached its lowest level since 1985.

#### Major changes compared to previous submission:

- Emission calculations are based now on IEA/Eurostat data for the period 1985-2012;
- Reference approach is reported in more categories following the IPCC fuel classification;
- Time dependent carbon emission factors for lignite have been introduced also for the years before 2005;
- Country specific emission factors derived on ETS data are used more extensively;
- Emissions from municipal waste incineration have been revised on the basis of fuel composition;
- Emissions from blast furnace gas used for energy purposes have been reallocated from Industrial Processes sector;
- Emissions from domestic aviation have been added.
- Notation keys and some EFs have been revised, and are used more consistently.
- Time series of emissions of indirect greenhouse gases and SO<sub>2</sub> are recalculated using the EMEP/EEA Guidebook consistently.

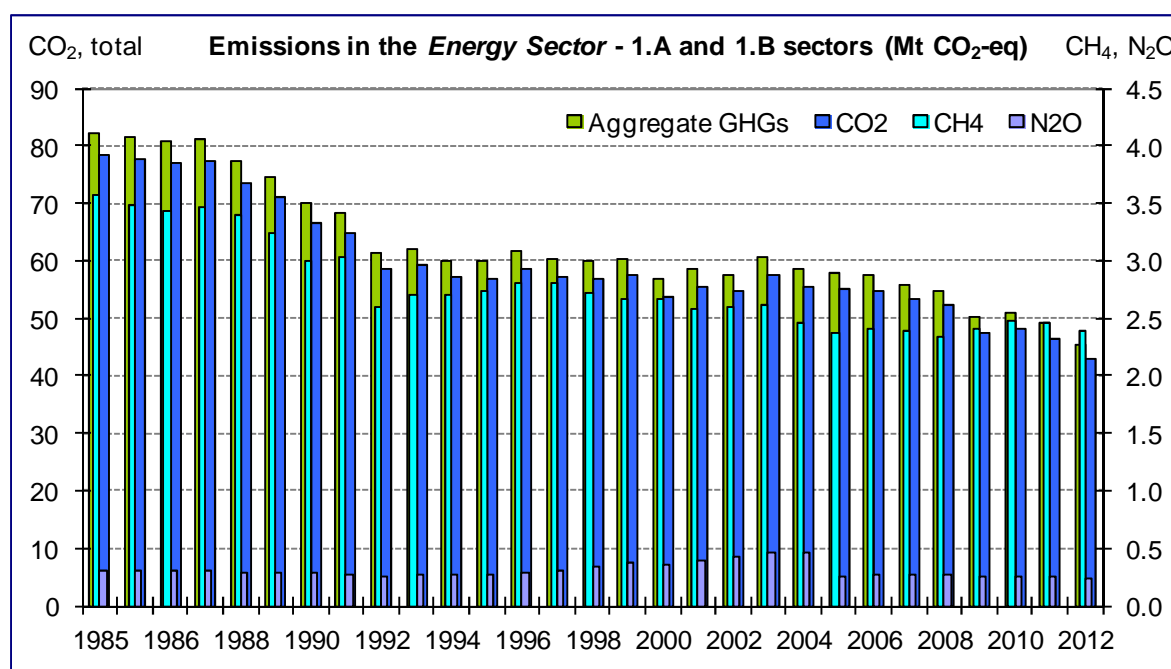
#### 3.1 Overview of sector

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

Methods: T1, T2, T3

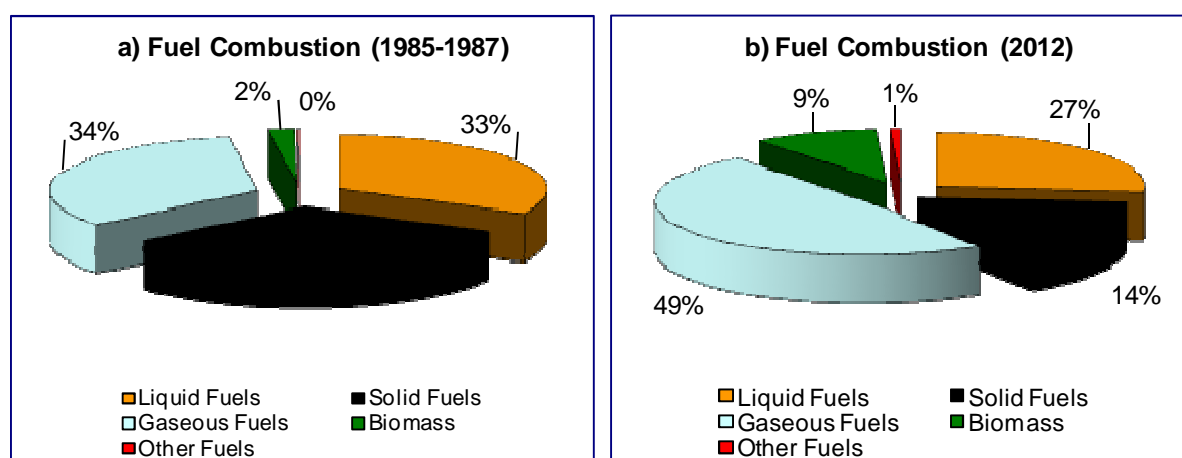
Emission factors: D, CS, OTH, PS

This sector covers emissions from combustion processes and fuel-related fugitive emissions from exploration, transmission, distribution and conversion of primary energy sources. *Figure 3.1.1* shows the emission trends in the sector by gases.



**Figure 3.1.1** CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Energy Sector (1985-2012)

The principal driver of emissions in this sector is fuel consumption. *Figure 3.1.2* represents the proportion of combusted fuel types in the base year and 2012.

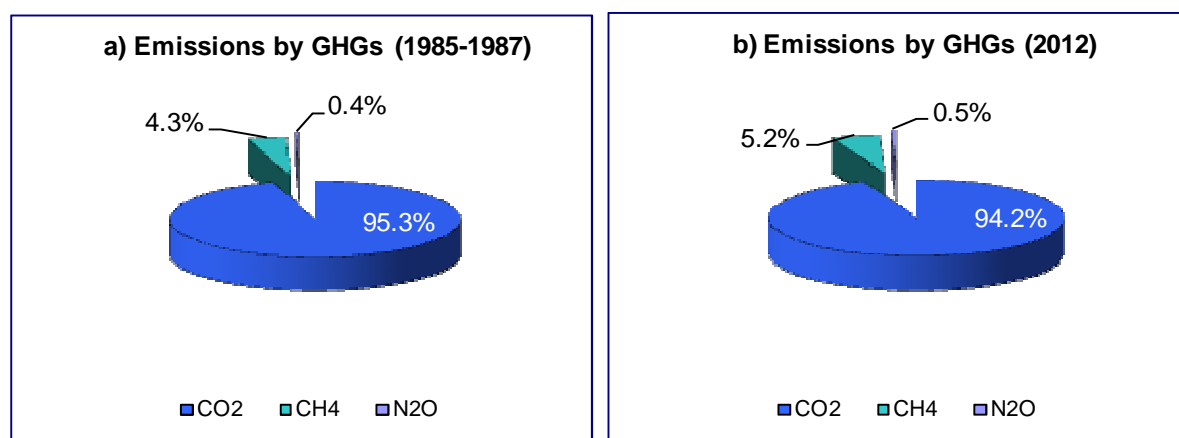


**Figure 3.1.2** Fuel combustion in the base year (a) and 2012 (b)

Carbon dioxide from fossil fuels is the largest item among greenhouse gas emissions. Its contribution is 94.2% to sectoral emission, followed by CH<sub>4</sub> with 5.2% and by N<sub>2</sub>O with 0.5%. Among fuels, gases have the highest proportion (49%), liquids and solid have less (27% and 14%) 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 5-6 years, Hungary experienced an almost constant emission reduction 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. In 2011 and 2012, emissions from the energy sector decreased further and reached their lowest level in the whole time series.

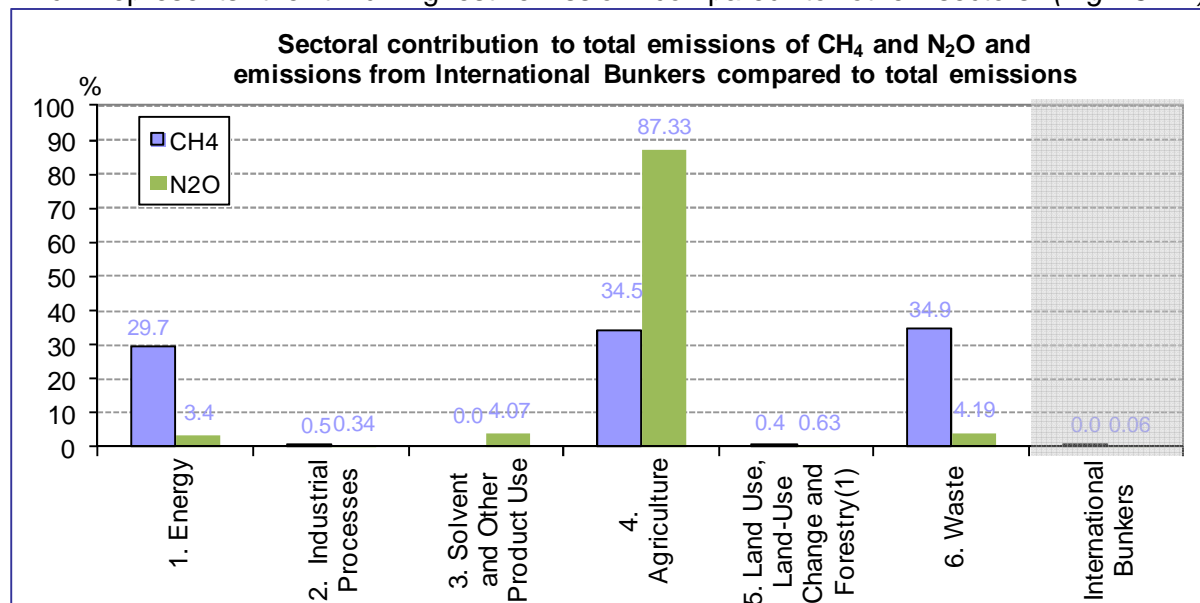
Overall emissions from the energy sector have decreased by 7.5% or 3.7 million tonnes between 2011 and 2012. The biggest change occurred in the "other sectors" (-13.2% or -1.8

million tonnes) mainly because natural gas consumption dropped by 13.5%. Commercial and public services purchased by a fifth less natural gas than in previous year, and we have not seen such a low consumption in the residential sector since the early 90's. Gross electricity production fell back by a further 3.9% (after a drop of 3.7% in 2011). Moreover, the decrease in natural gas based electricity production was the most pronounced (-12.5%), whereas the share of CO<sub>2</sub> neutral nuclear fuel has steadily grown in the last few years, and wind energy utilization showed a steep increase. In addition, electricity import grew significantly by 16% in 2012. Emissions from transport continued to decrease (-4.8%). Transport related emissions almost doubled between 1994 and 2007, since then, however, a decrease of 17.1% could be observed. Motor gasoline use has never been lower since 1990 than in 2011-2012, and road diesel consumption fell back as well (-7.9%). In addition, energy consumption of manufacturing industries decreased by 16.3%.



**Figure 3.1.3** Distribution of emission of GHGs in the Energy Sector in the base year (a) and 2012 (b)

As regards methane emission, this sector represents 4.1% (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 29.7%, which represents the third highest emission compared to other sectors (Fig. 3.1.4).

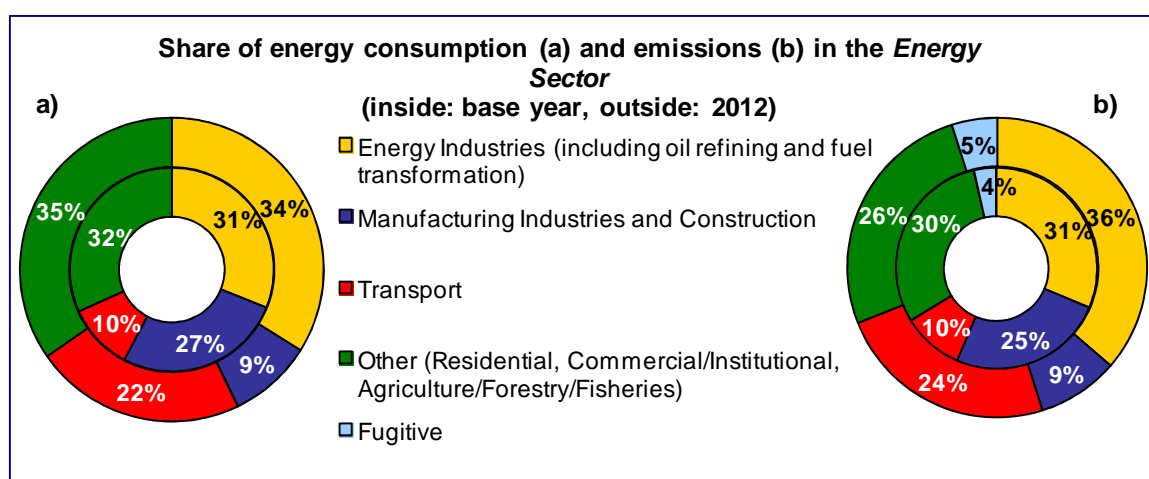


**Figure 3.1.4** Sectoral contributions to total emission of CH<sub>4</sub> and N<sub>2</sub>O in 2012

As regards nitrous oxide emission, this sector represents 0.4% (with LULUCF) of the total

greenhouse gas emission. Among nitrous oxide emitters, its proportion is 3.4% which represents the fourth highest emission compared to other sectors - far behind agriculture and about the same level with solvent use and waste sectors.

Emissions of the sector strongly depend on the amount of combusted fuel. *Fig. 3.1.5/a* illustrates the share of energy consumption among subsectors in this sector, while *Fig. 3.1.5/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 36%, followed by *Other Sectors* (1.AA.4) and *Transport* (1.AA.3) representing 26 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 9%. *Fugitive Emissions from Fuels* (1.B) play only a small role in emissions of the sector with 5%.



**Figure 3.1.5** Proportions of energy consumption and emissions in the Energy Sector in the base year and 2012

Calculation of greenhouse gas emissions from combustion is based on the amount of fuel used. For this purpose, the energy balance of Hungary, the fuel balance for each fuel type and the fuel consumption for each subsector prepared by the Hungarian Energy and Public Utility Regulatory Authority (previously: Energy Centre – Energy Efficiency, Environment and Energy Information Agency Non-Profit Company) were used dominantly. These energy statistics were available to the inventory compilers basically as hard copies of the publication series *Energy Statistical Yearbook*. For some years, also electronic versions (tables in Excel files) were provided. However, this publication ceased, the last yearbook contained data for 2010. After discussion with the energy statistics provider and following their recommendation, it was decided to build recent and all future inventories on the IEA/Eurostat Questionnaires. Even in years when the yearbooks were the most important source of activity data, also the IEA statistics were taken into account especially for its better coverage of renewable energy sources, but also as part of the QA/QC procedures. To increase internal consistency of the reporting, emissions have been recalculated for this submission - based now almost exclusively on IEA data, for the whole time series, back to 1985.

Input data for the fugitive emission calculation came from the Statistical yearbook of Hungary, Energy Statistics, the Hungarian Oil and Gas Company Plc. (MOL), the Hungarian Office for Mining and from the Hungarian Energy Office.

## 3.2 Fuel combustion (CRF sector 1.A)

### 3.2.1 Comparison of the sectoral approach with the reference approach

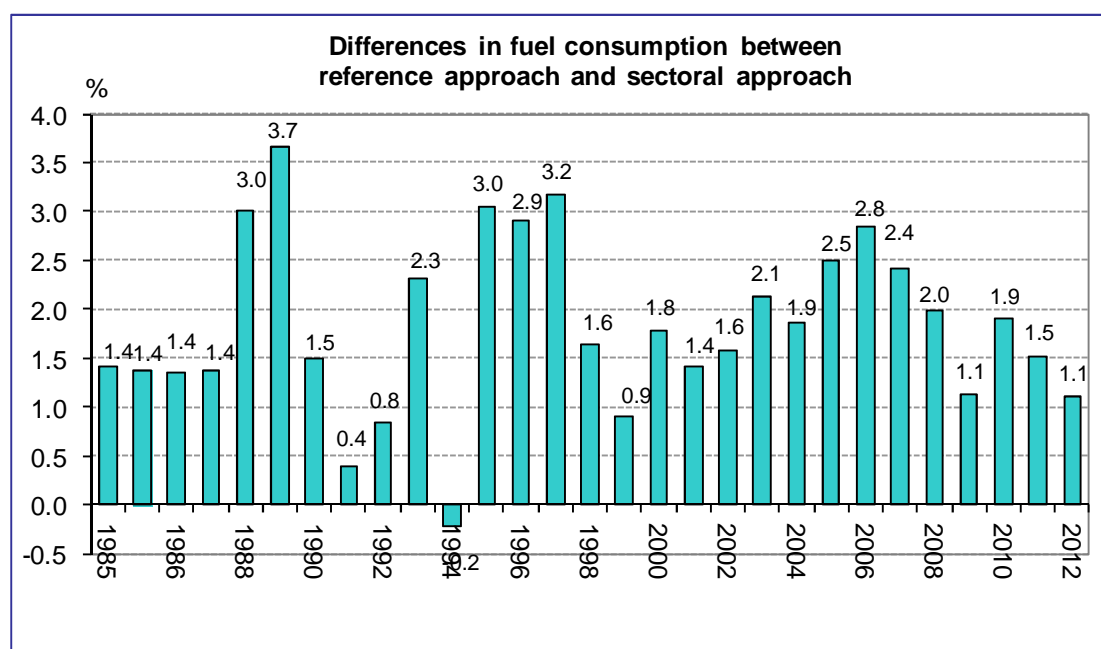
The quantity of CO<sub>2</sub> from energy consumption was determined on national level (*reference approach*) and on sectoral level (*sectoral approach*) as well.

The *reference approach* (RA) is based on national energy balance: production, import, export, stock changes, and international bunkers. The *sectoral approach* (SA) 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 2012 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.

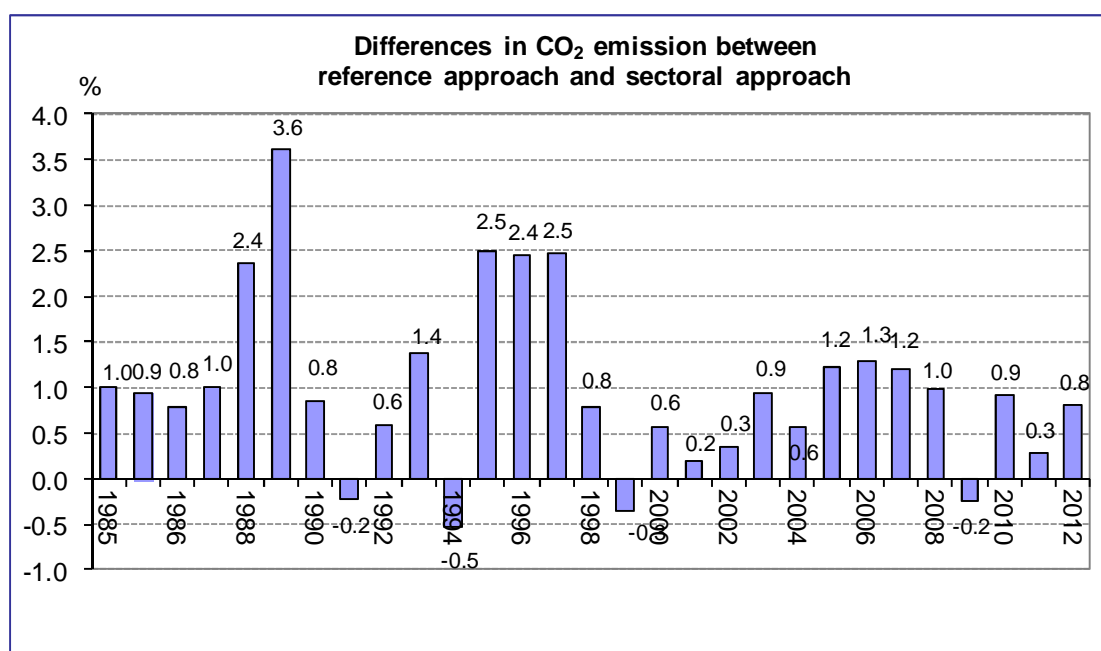
Emissions from feedstocks and non-energy use of fuels are taken into account in the Industrial Processes sector (2B and 2G) in case of *sectoral approach* (SA), therefore the energy and carbon content of these fuels are removed from the RA (the fraction of carbon stored is 1 for all these fuels in the 1D sector), too. Similarly, 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 3.1.6** 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 (*Fig. 3.1.6*). The remaining differences – after extracting the feedstock and non-energy use of fuels – are basically the fugitive emissions and the transformation losses which are occurring during coking, briquetting or oil refining.

In 2012, comparing the two approaches the difference was 1.1% in energy consumption (*Fig. 3.1.6*) and 0.8% as regards CO<sub>2</sub> emission (*Fig. 3.1.7*). The ranges of differences are between -0.2% (1994) and 3.7% (1989) with a 1.8% mean value as regards the fuel consumptions, and -0.5% (1994) and 3.6% (1989) with a 1.0% mean value as regards the CO<sub>2</sub> emissions. Generally, the differences are smaller for the years after 1998.



**Figure 3.1.7** Comparison of sectoral and reference approach – CO<sub>2</sub> emission

For this submission, also the reference approach has been calculated based on the IEA data which is in line with the ERT's recommendation to use the Revised 1996 IPCC Guidelines coal classification to ensure consistency and comparability of the CRF and NIR data. The Hungarian traditional coal terminology as published in the Energy Statistical Yearbooks differs from that of the IPCC. The partitioning is created according to the age of coal; *Table 3.1.1* 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. Basically, most of the coal produced in Hungary can be classified as lignite. Furthermore, the Energy Statistical Yearbook dealt with coking coal, hard coal, brown coal and lignite in the fuel balance separately, while the sectoral energy consumption for coal was the aggregate of hard coal, brown coal, lignite, gas coal and coking coal. Now, the reported fuel data follow the IPCC categories and are consistent with the IEA statistics as well. In addition, in case of liquid fuels more fuel categories are reported than previously (e.g. naphtha and gasoline are reported separately, lubricants and refinery feedstock have been added etc.) and the share of non-energy use has also been revised to be more consistent with the data submitted to the IEA. LPG and petroleum coke were taken into account as liquid fuels.

As regards carbon emissions, solid fuels caused the most problems mainly because the fuel classification had been changed. The formerly used country specific carbon emission factors were previously determined for the Hungarian categories, namely for hard coal, brown coal, and lignite. (The following constant values were used based on the 2005 ETS data: 27 tC/TJ for hard coal and brown coal and 30.9 tC/TJ for lignite.) Now, new factors had to be applied for other bituminous coal, sub-bituminous coal and lignite. Most of the coal produced in Hungary can be classified as lignite in this new system irrespectively whether it stemmed from surface or underground mines, although they have different characteristics. To take into account the changing share of the higher quality lignite from underground production, a time dependent carbon emission factor (changing between 27.4 and 29.9 t C/TJ) was introduced and applied for the pre-ETS years. For the lowest quality lignite from surface mines the following parameters are used: EF=112.2 t CO<sub>2</sub>/TJ, OX=0.974. As for Hungarian brown coal EF=100.8 t CO<sub>2</sub>/TJ and OX=0.952 is applied. It is worth noting that the share of the lower quality lignite in production increased from 20% in 1990 to 84% in 2010. For other bituminous coal and sub-bituminous coal, default values are used.

**Table 3.1.1** 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)

### 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 3.1.2 which shows the air travelling/transport performance of the past years.

**Table 3.1.2** Air travelling and transport performance in Hungary since 2000 in selected years

Air transport	2000	2005	2007	2008	2009	2010	2011	2012
Passengers carried (thousands)	2,476	3,785	4,896	4,340	4,573	4,512	4,875	2108
Transported quantity of goods (kt)	22	16	17	14	16	16	12	7
Quantity of kerosene (TJ)	8,957	9,368	10,145	11,303	10,584	9,618	9,660	7,014

(Source: HCSO, 2013; Hungarian Energy and Public Utility Regulatory Authority)

Emissions from in-country aviation, which represent a very low proportion, were previously 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. For this submission, also some kerosene use was added to domestic aviation based on data collected by Eurocontrol.

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. International sea navigation (there was only tramp navigation) has relapsed: between 1990 and 2000 the role of transportation of goods on waterways decreased from 28.2% to 2.9% among goods transportation. The last two ships were sold in 2004.

### 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*. In addition, 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 3.1.3*.

**Table 3.1.3** 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.B
Natural gas (not used in 2B)	Industrial processes – Feedstock and non-energy use of fuels	2.G
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

Coal and petroleum coke serve as additives increasing the porosity of bricks, therefore emissions of these fuels are calculated in the *Industrial Processes Sector* using the EU ETS database of manufacturing bricks and ceramics.

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 or country specific factors of carbon stored (*Table 3.1.4*) are used in the appropriate industrial processes sector for the calculation of CO<sub>2</sub> emissions.

**Table 3.1.4** 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)	Fraction of carbon stored used in 2.G (country specific values in italics)
Naphtha	0.8	<i>0.778</i>
Gas/Diesel Oil	0.5	<i>0.512</i>
LPG	0.8	<i>0.749</i>
Other oils	lubricants: 0.5, other: 0.8	lubricants: 0.5 paraffin waxes and SBP and white spirit: 0.8 <i>other oil products: 0.455</i>
Natural Gas (not reported in 2B)	0.33	0.33

### 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 without analysis. 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 3.1.5*. 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 3.1.5** Country specific emission factors derived from the EU ETS database

	Default	2008	2009	2010	2011	2012
Gasoil	20.2	20.2	21.6	22.5	20.6	20.5
Heavy fuel oil	21.1	22.4	21.0	21.1	21.4	21.4
Other oil	20.0	21.8	21.9	21.8	21.9	21.8
Lignite	27.6	29.5	29.8	29.9	29.8	29.7
Blast furnace gas	66.0	69.7	69.0	66.4	69.3	70.9
Coke oven coke	29.5	30.8	30.6	30.6	30.4	30.9
Coal/petroleum coke	-	25.7	25.9	25.4	25.5	25.2
Natural gas	15.3			15.2	15.2	15.2

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 sources:

Public Electricity and Heat Production – Gas – CO<sub>2</sub>: L1, T1,

Public Electricity and Heat Production – Liquid – CO<sub>2</sub>: T1

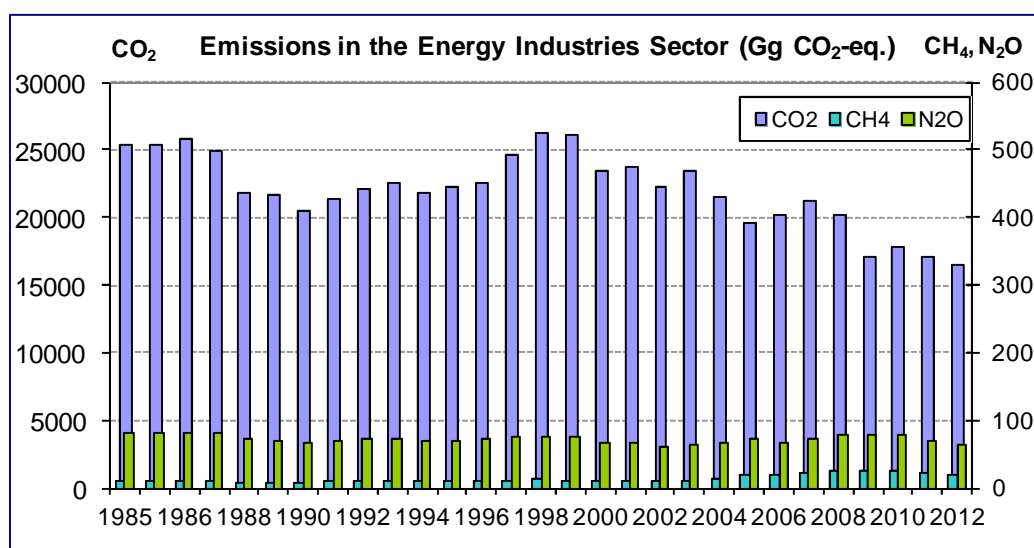
Public Electricity and Heat Production – Solid – CO<sub>2</sub>: L1, T1

Public Electricity and Heat Production – Other – CO<sub>2</sub>: L1, T1

Petroleum Refining – Gas – CO<sub>2</sub>: L1;

Petroleum Refining – Liquid – CO<sub>2</sub>: L1.

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.



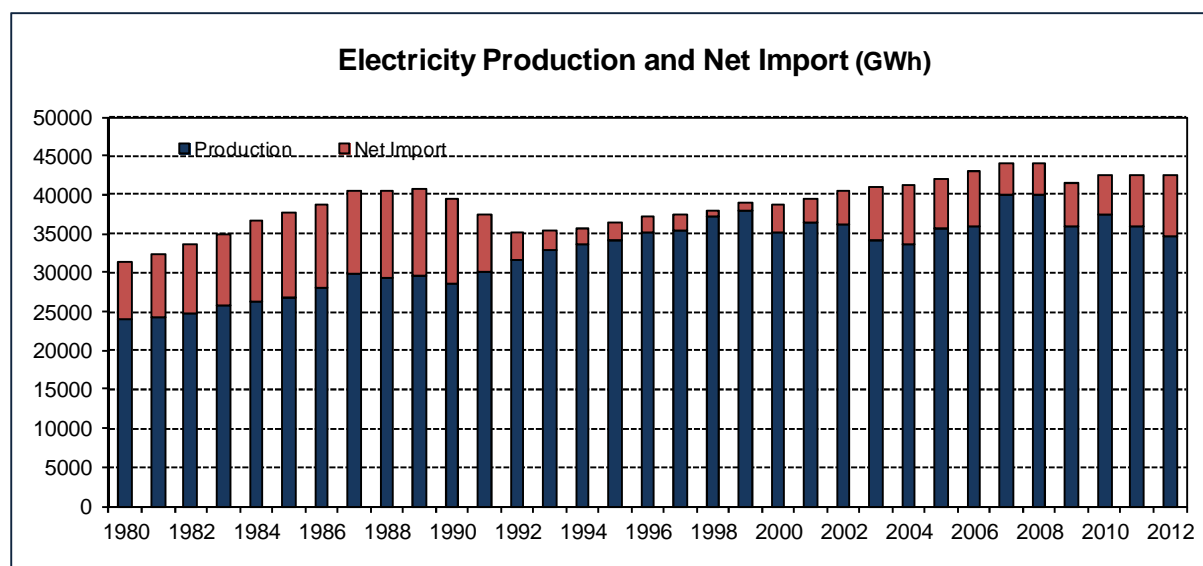
**Figure 3.1.8** Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Energy Industries (1985-2012)

Public Electricity and Heat Production is responsible for almost 90% of fuel use in energy industries. For heat and electricity production 365 PJ energy was used which is 37% of total domestic consumption. The energy source consumption of power plants was 4.6% less than in previous year. 47.2% of consumed energy sources was nuclear fuel, 23.3% was natural gas and 19.2% was coal in 2012. The wastes and renewable energy sources used in power plants gave 9.7% of total energy source consumption of power plants. Domestic electricity production showed an overall increasing trend; even during the years of the regime change around 1990, whereas import suffered a more severe drop from 28% to 10%. The share of import is a highly variable figure, in the last decade it changed between 8% (2001) and 19% (2012). However, in the last few years, electricity import showed an increasing tendency, An interesting incident occurred in 2009 when domestic production fell back by more than 10% whereas consumption decreased only by 6%. There was a multi-week break in the natural gas supply through Ukraine, thus the electricity generation of our natural gas firing power plants had to be substituted by import electricity and by increased production of oil fired power plants.

In 2011 there were considerable changes in several areas of the Hungarian Power System. On the generation side, AES Borsodi Energetikai Kft. (AES Borsod Heat PP Ltd), being under liquidation, ceased its electricity generation. This meant that two coal and partly biomass firing power plants were closed. However, new units were added to the system: the combined cycle power plant of E.On Erőmű Kft. (E.On Power Plant Ltd.) in Gönyű and the open cycle gas turbine power plant of BVMT Bakonyi Villamos Művek Termelő Zrt. (BVMT Bakony Power Generation Ltd.). In addition, the amendment of the operating licence of Dunamenti Erőmű Zrt. (Dunamenti Power Plant Ltd.) enabled the commercial operation of a GT3 unit.

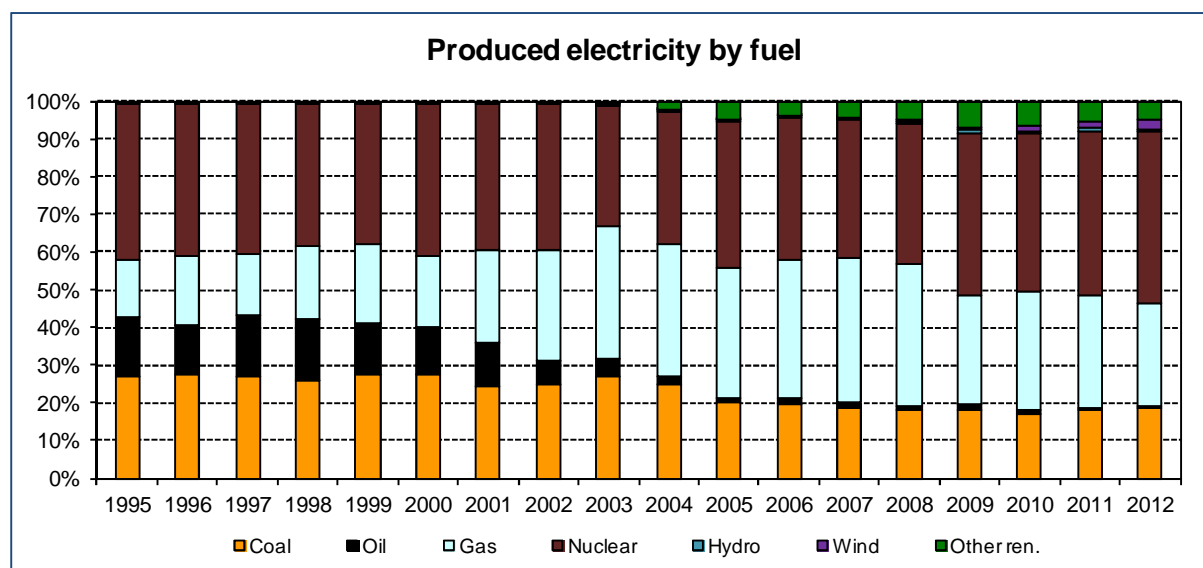
*“Since the regional supply and demand factors affect the electricity market, the utilisation of domestic power plants is strongly influenced by the fuel costs and the regional wholesale electricity prices changing country by country. The gas-fired power plants have lost significant market share also in our region due to the high and basically oil price-indexed gas prices, the drop in electricity consumption, the collapse of CO2 allowance price system and the increase of electricity generation from renewables. Consequently, the load factor of domestic power plants was low. The traders compensated the loss of domestic generation from import. Thus the amount of import-export balance reached 18.8% of total domestic electricity consumption in 2012.”*

(Source: STATISTICAL DATA OF THE HUNGARIAN POWER SYSTEM, 2012)



**Figure 3.1.9 Domestic Electricity Production and Net Import (1980-2012)**

Naturally, as domestic emissions are related to domestic production, the yearly fluctuation of production is one of the decisive factors. Not less important is the way how electricity is produced, e.g. what energy source is used. In Hungary, this sector consumes the deterministic part of our solid fossil fuel production. However, some uneconomical coal-fired power plants of low efficiency were stopped, and blocks of combined-cycle-gas turbine units were installed. For example, new 150 MW combined cycle gas-turbine units were installed (Újpest, Kelenföld, Százhalombatta, Nyíregyháza Power Plants), and aged coal fired units (Inota, Bánhida) of low efficiencies were taken out of service or blocks have been converted to the combustion of biomass (Pécs, Kazincbarcika, Ajka Power Plants). The demand for fossil fuel decreased by about 150 PJ in the electricity sector between 1980 and 1990 because of the penetration of nuclear electricity into the electricity market. This means that the fossil fuel consumption of public power plants is smaller now than it was before the introduction of nuclear electricity generation, in spite of much higher domestic electricity production. As a promising new development, increasing use of renewable sources could be observed by some public power plants. All these developments are demonstrated in Figure 3.1.10.



**Figure 3.1.10** Share of produced electricity by fuel (1995-2012)

### 3.2.6.2 Methodological issues

#### Activity data

Energy consumption data were taken from the IEA annual questionnaires compiled by the Hungarian Energy and Public Utility Regulatory Authority. Besides, waste statistics and ETS data were taken into account.

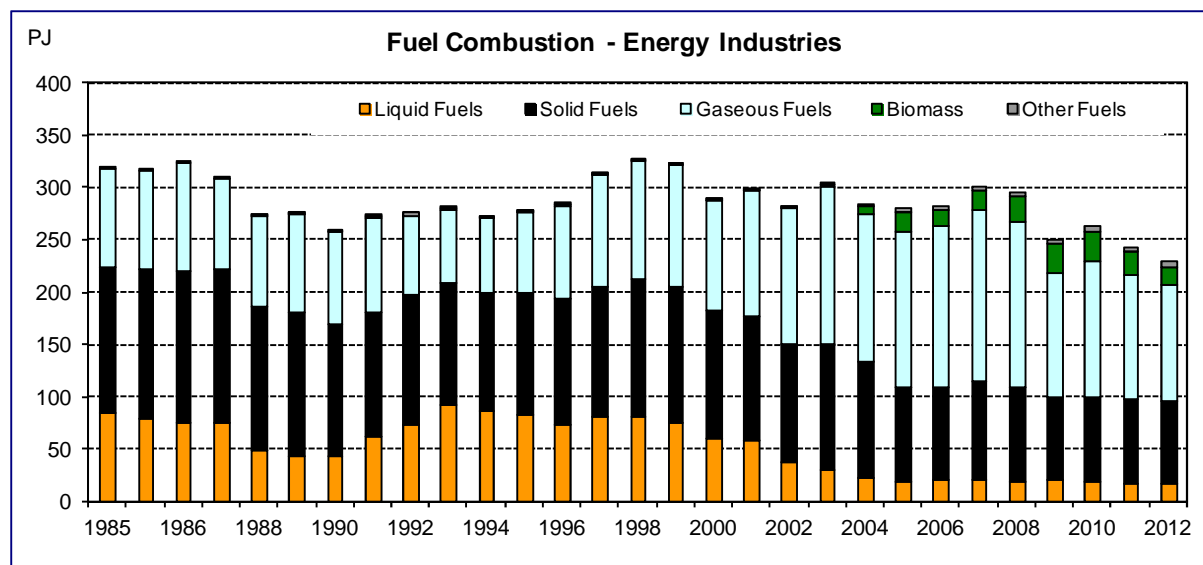
As it can be seen in *Figure 3.1.11*, total fuel consumption in the energy industries sector shows strong fluctuations. Of course, we had a significant decrease around the political and economic regime change in 1990, then a pronounced increase till 1998, then a decrease till 2005 and a quite significant 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 3.1.11*. 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 due to favorable terms 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, and 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%.

In 2011, electricity production fell back by 3.7% which meant lower fuel use at power plants. Moreover, the decrease in fossil fuel use was more pronounced, whereas there was only a slight change in GHG irrelevant nuclear fuel use.

In 2012, gross electricity production fell back by a further 3.9%. Moreover, the decrease in natural gas based electricity production was the most pronounced (-12.5%), whereas the share of CO<sub>2</sub> neutral nuclear fuel has steadily grown in the last few years, and wind energy

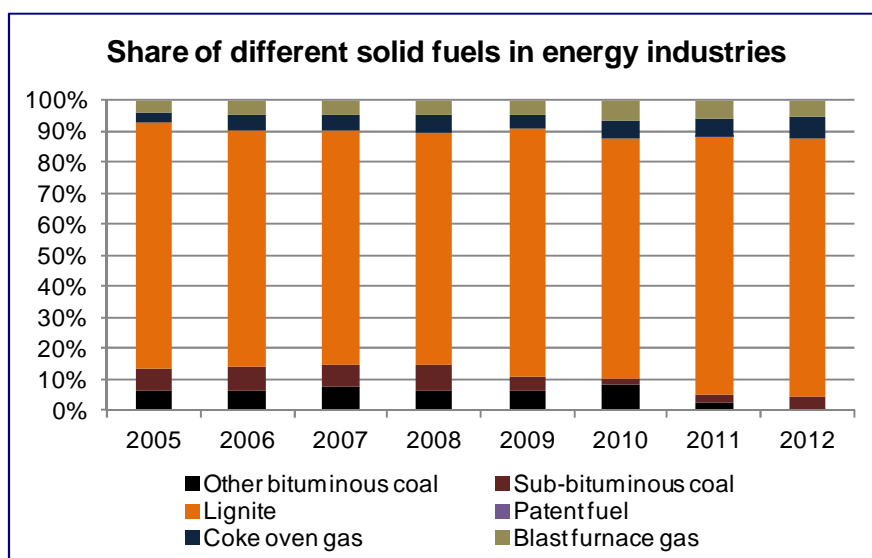
utilization showed a steep increase. In addition, electricity import grew significantly by 16% in 2012.

The fuel consumption of oil refining showed a pronounced drop around 2000. Currently its share is about 10%. Even less significant is manufacture of solid fuels with a portion of 2% within energy industries.

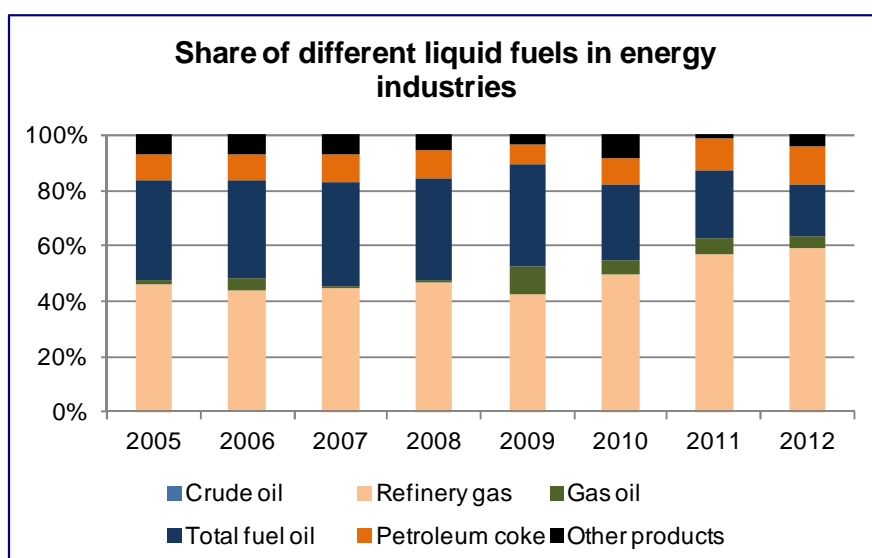


**Figure 3.1.11** Fuel combustion in the Energy Industries Sector (1985-2012)

Going into more detail regarding fuel use, it can be seen that domestically produced lignite is the dominant fuel among solid fuels (*Fig. 3.1.12*). In energy industries, solid and gaseous fuels are dominant representing together 83% of all fuel use. In contrast, liquid fuel use became almost negligible in electricity and heat generation. Nevertheless, refinery gas used in oil refinery became the most important liquid fuel type (*Fig. 3.13*).



**Figure 3.1.12** Share of different solid fuels used by energy industries (2005-2012)



**Figure 3.1.13** Share of different liquid fuels used by energy industries (2005-2012)

Traditionally, refinery gas and heavy fuel oil were reported together in the Hungarian Energy Statistical Yearbooks. Expressed in mass units, three-four times more refinery gas is used in the refinery as fuel oil.

However, as the ETS data show, refinery gases have significantly different characteristics. Based on plant specific information from the period 2008-2012, “real” heavy fuel oil burned by the refinery has a net calorific value between 39.8 TJ/kt to 40.2 TJ/kt and a CO<sub>2</sub> emission factor between 82.1 t/TJ and 83.7 t/TJ. Refinery gases show in contrast more diverging values. We can see here calorific values between 45.6 TJ/kt and 64.2 TJ/kt with corresponding CO<sub>2</sub> emission factors between 35.3 t/TJ and 60.6 t/TJ. On average, it can be calculated with a NCV of 49.2-49.7 kt/TJ and an EF of 50.8-51.8 t/TJ for refinery gases.

There are some differences between the classification of fuels in the plant and in the energy statistics. However, considering these fuels together, we could see a better agreement. Therefore it seemed appropriate to handle them in an aggregate manner and to use the following parameters: 50 t/TJ as aggregate NCV and 59 t/TJ as aggregate CO<sub>2</sub> emission factor, at least for the period 2001-2007 with high share of refinery gas consumption. For the 90's, where the share of refinery gas was definitely lower with 37% on average, separate factors were applied as summarized in the following table.

**Table 3.1.6** Country specific parameters used in the category petroleum refining

Period	Fuel	Avg. NCV [TJ/kt]	EF [t CO <sub>2</sub> /TJ]	Comment
2008-2012	refinery gas	49.2-49.7	50.8-51.8	ETS data
2008-2012	other liquid fuel	40.0-40.2	81.7-82.7	ETS data
2001-2007	mixed fuel	50.0	58.7	country specific
1985-2000	refinery gas	49.5	51.3	country specific
1985-2012	petroleum coke	29.4	117.3	EF based on mass

### Emission factors

Carbon dioxide emissions were calculated in accordance with the Revised 1996 Guidelines. Country specific OF and EF values – taken mostly from the ETS database – were used for most solid fuels and some liquids. The used factors are summarized in Table 3.1.7.

**Table 3.1.7** CO<sub>2</sub> emission factors used in energy industry in the 2012 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>99.3</b>	<b>1.00</b>
<b>Sub-Bituminous Coal</b>	<b>99.5</b>	<b>1.00</b>
<b>Lignite (domestic brown coal)</b>	<b>110.5</b>	<b>0.937</b>
<b>Lignite (domestic lignite)</b>	<b>112.0</b>	<b>0.970</b>
BKB	94.6	0.98
Coke Oven/ Gas Coke	108.17	0.98
Coke Oven Gas	47.7	0.995
<b>Blast Furnace Gas</b>	<b>260.0</b>	<b>0.995</b>
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>75.2</b>	<b>0.997</b>
<b>Residual Fuel Oil</b>	<b>78.6</b>	<b>0.997</b>
<b>RFO in refinery</b>	<b>82.1</b>	<b>0.995</b>
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>0.995</b>
<b>Natural Gas</b>	<b>55.6</b>	<b>1.00</b>
<b>NG in coking plant</b>	<b>55.8</b>	<b>1.00</b>
Biomass (Solid)	109.63	0.99
Biogas	54.6	0.995
<b>Waste</b>	<b>70.0*</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.

More information on country and plant specific CO<sub>2</sub> emission factors based on ETS data 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 are generally used as it can be seen in the following table:

**Table 3.1.8** Emission factors for methane and nitrous oxide in energy industry

Emission	Factors (kg/TJ)	
	CH <sub>4</sub>	N <sub>2</sub> O
Fuel type		
Coal	1.0	1.4
Derived gases	1.0	0.1
Natural Gas	1.0	0.1
Liquid fuels	3.0	0.6
Firewood	30.0	4.0
Biogas	1.0	0.1
Wastes	30.0	4.0

Please note that regarding non-CO<sub>2</sub> emissions, for coal, Hungary has consistently switched to the default emission factors from the 1996 IPCC Guidelines. In case of derived fuels and biogases, as no detailed information is available in the 1996 IPCC Guidelines, default factors were taken from the 2006 IPCC Guidelines.

As recommended by the ERT and required by the guidelines, the emissions from waste incineration for energy purposes have been 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 and composition of waste serve as basis of calculations. For our calculations three main activity data sources were used: data from the Waste Incineration Works (FKF) of Budapest (1985-2012), the Hungarian Waste Management Information System (2004-2012), the IEA Renewable Questionnaire, and the ETS data (2006-2012). 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).

In previous submission, mass of incinerated waste was converted to energy using estimated or derived conversion factors. For this submission, incinerated waste data expressed in energy unit were directly taken out from the IEA statistics. It should be stressed, however, that the reported TJ values are not used for CO<sub>2</sub> emission estimations therefore the resulting IEF values have little significance.

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, country-specific waste amount and composition data were needed, and the emission factors could be 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 5.0% in 1990 and 17.3% in 2012 showing thus a growing trend. CO<sub>2</sub> emissions were estimated then with an oxidation factor of 1.0.

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.

Also 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 250-340 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%.

Consistency of the time series has been improved as generally the IEA/Eurostat questionnaires serve as activity data.

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

Energy consumption data were subject of several rounds of verification before use. National energy statistics as published in the yearbooks were compared with the statistics provided to international organizations (both prepared by the same institute). This verification pointed out some problems also previously (e.g. on coke oven/blast furnace gas use, missing refinery gas and petroleum coke consumption) which were corrected. This work has been extended, and a comprehensive consistency check between data in the IEA time series and the Hungarian Energy Statistical Yearbooks has been conducted. Based on the results of this consistency check, and after several consultations with the energy statistics provider, it was decided to build the calculations on the IEA/Eurostat questionnaires.

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 from the 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.

In the inventory, emissions from natural gas were estimated using default calorific values and emission factors. For a justification of this approach, about 40 emission reports from the ETS had been analyzed. Using the same activity data as reported by these facilities, we have calculated CO<sub>2</sub> emissions with default parameters and compared our results with the reported CO<sub>2</sub> emissions from the ETS database. It turned out that the difference was minor: with default parameters the emissions were overestimated only by 0.4%. This small difference allowed us to change our previous approach for this submission. To be more consistent with the emissions reported under the ETS regime, we have switched to country specific emission factors for 2010-2012.

A comparison between ETS and inventory data was also made for the coking plant. The difference was higher here. In our recent inventory, CO<sub>2</sub> emissions from solid fuels differed from ETS data by between -4% (2011) to 17% (2010). Emission calculations show a better agreement for 2012 though: CO<sub>2</sub> emissions reported for 2012 are by only 2% higher as in the

ETS database.

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 have been substantially recalculated for this submission. The most important elements of the recalculations are as follows:

- The **IEA/Eurostat questionnaires** serve as activity data instead of the Energy Statistical Yearbooks;
- **Re-derived emission factors for lignite** for the period 1985-2004. Instead of constant EFs used previously, changing ratio of lignite from underground and surface mines are now taken into account;
- **Reallocation emissions from blast furnace gas used for energy purposes** from 2.C.1.4 Iron and Steel/Coke. Blast furnace gas consumption as activity data were taken from the IEA questionnaires. As for emission factors, plant specific data were derived from the ETS database for 2006-2012, and their average value, i.e. 255.7 t CO<sub>2</sub>/TJ, was used for the preceding years. Table 3.1.9 summarizes the effects of the recalculation.
- **Recalculation of emissions (and activity data) from waste incineration.** Previously, the fuel content of the waste was estimated by using the amount of incinerated waste with a constant calorific value of 8.5 GJ/t waste. In this submission, we moved toward IEA data, and fuel consumption data were directly taken from the IEA questionnaire "Renewables and Wastes". In the Hungarian submission to the IEA, 50 per cent of the incinerated municipal waste is considered as renewable and the other half as non-renewable consistently for the entire time series. Please note that in the CRF tables the total amount is reported. Nevertheless, not the fuel content of the waste (TJ) but the waste amount (kt) was used for the estimation of CO<sub>2</sub> emissions both in previous and current submission. In the previous submission, for the years before 2004, 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. Now, in this submission, our calculations are based on yearly changing waste composition data for the entire time series. 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. Waste composition changed quite significantly in the last decades, which is reflected in the changing (i.e. increasing) implied emission factor. Most importantly, the share of plastics that was less than 5 per cent in 1990 grew to 21.2 per cent in 2012 which means a significant increase in incinerated fossil carbon. Table 3.1.10 below summarizes the resulting changes.
- **Use of country-specific emission factor for natural gas** for the years 2010-12 (55.3, 55.6, and 55.6 t CO<sub>2</sub>/TJ) based on ETS data of larger power plants. The resulting change for 2011 is -20.4 Gg, or -0.3 per cent, so it cannot be regarded as significant.
- **Plant specific CO<sub>2</sub> emission factors** based on ETS data has been introduced for natural gas for the years 2008-2012 also in petroleum refining as follows: 56.1; 56.0; 56.6; 55.3; 55.6 t CO<sub>2</sub>/TJ. The resulting change for 2011 is -5.0 Gg, or -0.9 per cent.
- The same as above, **plant specific CO<sub>2</sub> emission factors** based on ETS data has been introduced for natural gas in Manufacture of Solid Fuels and Other Energy Industries but only for the years 2010-2012 (56.1; 56.2; 55.8 t CO<sub>2</sub>/TJ) which meant an increase of 0.7 per cent in 2011.

- For non-CO2 emissions, default EFs from the 1996 IPCC Guidelines are used consistently. In cases when no default EF was available, e.g. derived fuels, biogases, the emission factors were taken from the 2006 IPCC Guidelines.

**Table 3.1.9** Effects of recalculation in 1.A.1.a Public Electricity and Heat Production in relation with solid fuels

	SOLID FUEL USE (TJ)			CO2 EMISSION (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
<b>1985</b>	139,945	137,101	-2.0%	14,223.6	13,519.8	-4.9%
<b>1985-87</b>	143,702	141,183	-1.8%	14,582.4	13,912.6	-4.6%
<b>1986</b>	145,085	143,063	-1.4%	14,714.9	14,089.9	-4.2%
<b>1987</b>	146,075	143,385	-1.8%	14,808.9	14,128.2	-4.6%
<b>1988</b>	135,718	134,116	-1.2%	13,619.4	13,152.4	-3.4%
<b>1989</b>	129,878	133,307	2.6%	13,046.5	13,114.7	0.5%
<b>1990</b>	126,496	124,395	-1.7%	12,725.3	12,266.1	-3.6%
<b>1991</b>	118,603	116,294	-1.9%	11,971.6	11,471.6	-4.2%
<b>1992</b>	122,329	120,629	-1.4%	12,451.1	12,075.0	-3.0%
<b>1993</b>	116,585	113,871	-2.3%	11,930.6	11,436.0	-4.1%
<b>1994</b>	110,583	108,391	-2.0%	11,351.8	10,902.9	-4.0%
<b>1995</b>	113,962	114,165	0.2%	11,703.7	11,513.2	-1.6%
<b>1996</b>	117,792	118,016	0.2%	12,137.6	11,915.4	-1.8%
<b>1997</b>	121,176	120,489	-0.6%	12,498.8	12,190.8	-2.5%
<b>1998</b>	120,525	127,964	6.2%	12,402.5	13,501.4	8.9%
<b>1999</b>	122,393	127,704	4.3%	12,615.8	13,528.0	7.2%
<b>2000</b>	118,607	119,676	0.9%	12,260.0	12,781.0	4.2%
<b>2001</b>	111,513	115,532	3.6%	11,610.8	12,355.1	6.4%
<b>2002</b>	107,577	111,704	3.8%	11,190.8	11,982.7	7.1%
<b>2003</b>	116,889	116,954	0.1%	12,208.8	12,558.6	2.9%
<b>2004</b>	107,969	107,996	0.0%	11,340.9	11,840.8	4.4%
<b>2005</b>	84,399	89,031	5.5%	8,942.7	9,816.1	9.8%
<b>2006</b>	81,274	85,299	5.0%	8,758.0	9,720.0	11.0%
<b>2007</b>	85,388	89,683	5.0%	8,890.6	10,038.9	12.9%
<b>2008</b>	82,105	86,283	5.1%	8,495.9	9,561.9	12.5%
<b>2009</b>	71,949	75,837	5.4%	7,548.6	8,510.2	12.7%
<b>2010</b>	71,830	77,068	7.3%	7,526.0	8,735.5	16.1%
<b>2011</b>	72,700	77,392	6.5%	7,651.4	8,838.4	15.5%
<b>AVG</b>			<b>1.6%</b>			<b>3.1%</b>

**Table 3.1.10** Effects of recalculation in 1.A.1.a Public Electricity and Heat Production in relation with waste incineration

	WASTE FUEL USE (TJ)			CO2 EMISSION (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	2,071	1,766	-14.7%	101.09	45.62	-54.9%
1985-87	1,999	1,571	-21.4%	97.62	44.08	-54.9%
1986	1,859	1,478	-20.5%	90.76	40.98	-54.9%
1987	2,069	1,470	-28.9%	101.01	45.63	-54.8%
1988	1,671	1,153	-31.0%	81.59	36.87	-54.8%
1989	605	444	-26.6%	29.55	13.36	-54.8%
1990	1,288	988	-23.3%	62.87	27.82	-55.7%
1991	2,151	1,618	-24.8%	105.04	44.65	-57.5%
1992	2,889	2,148	-25.7%	141.06	58.08	-58.8%
1993	2,684	2,118	-21.1%	131.06	66.89	-49.0%
1994	2,870	2,470	-14.0%	140.15	71.78	-48.8%
1995	2,804	2,170	-22.6%	136.91	50.48	-63.1%
1996	2,808	2,374	-15.5%	137.12	59.53	-56.6%
1997	2,885	2,400	-16.8%	140.85	95.21	-32.4%
1998	3,029	2,494	-17.7%	147.86	111.25	-24.8%
1999	2,994	2,466	-17.6%	146.16	135.91	-7.0%
2000	2,959	2,436	-17.7%	144.46	108.41	-25.0%
2001	3,000	2,598	-13.4%	146.45	139.09	-5.0%
2002	2,190	1,996	-8.8%	106.90	124.17	16.2%
2003	1,634	1,508	-7.7%	99.42	88.00	-11.5%
2004	1,766	1,374	-22.2%	106.44	75.40	-29.2%
2005	4,067	2,918	-28.3%	240.68	153.58	-36.2%
2006	4,572	4,327	-5.4%	258.77	245.17	-5.3%
2007	4,664	4,582	-1.8%	336.13	324.84	-3.4%
2008	4,192	3,926	-6.3%	285.10	274.56	-3.7%
2009	4,126	3,906	-5.3%	269.78	270.39	0.2%
2010	4,486	4,486	0.0%	279.37	280.04	0.2%
2011	4,188	4,188	0.0%	278.52	279.17	0.2%
AVG			-16.4%			-31.6%

### 3.2.6.6 Source-specific planned improvements

Our major planned improvement is the adaptation of the 2006 IPCC Guidelines. The general consistency analysis of ETS and inventory data will be continued.

### 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 sources:

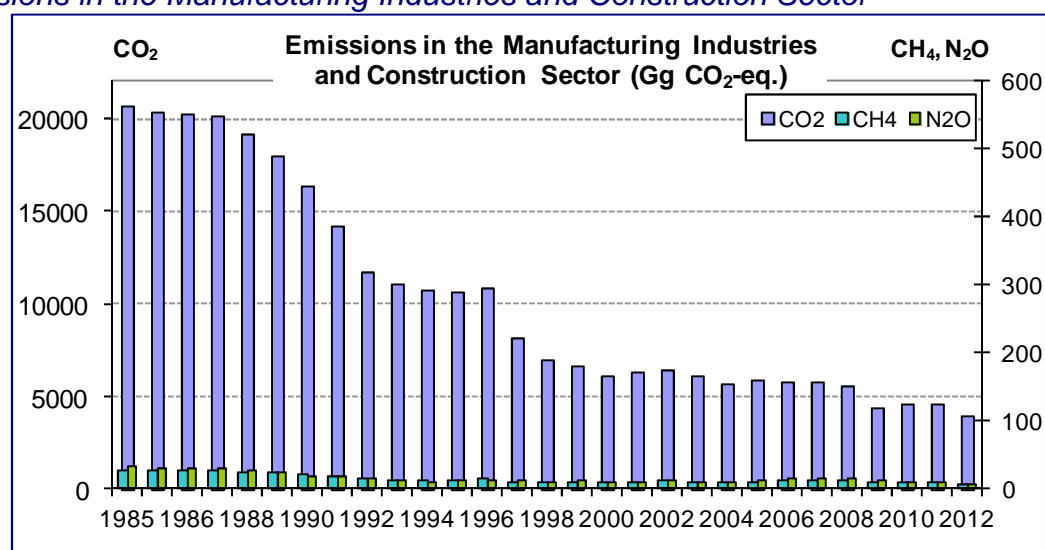
Manufacturing Industries and Construction – Gas – CO<sub>2</sub>: L1, T1;

Manufacturing Industries and Construction – Liquid – CO<sub>2</sub>: L1, T1

Manufacturing Industries and Construction – Solid – CO<sub>2</sub>: L1, T1

This subsector covers emissions from the combustion of fuels in the industrial sector. One of the advantages of using the IEA/Eurostat questionnaires instead of the energy statistical yearbooks is that the industrial sectors in the questionnaires and in the CRF tables can be more easily harmonized. In this submission emissions from autoproducers have been added as a new category to the *Other* subsector (1.AA.2.F). Furthermore, emissions from blast furnace gas have been reallocated from the Industrial Processes sector (2.C).

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



**Figure 3.1.14** Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Manufacturing Industries and Construction Sector (1985-2012)

#### 3.2.7.2 Methodological issues

The energy consumption data have also here been recalculated on the basis of the IEA/Eurostat questionnaires. All feedstock and non-energy use were removed from the *Chemicals* subsector for the entire time-series, and all relating CO<sub>2</sub> emission originating 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.

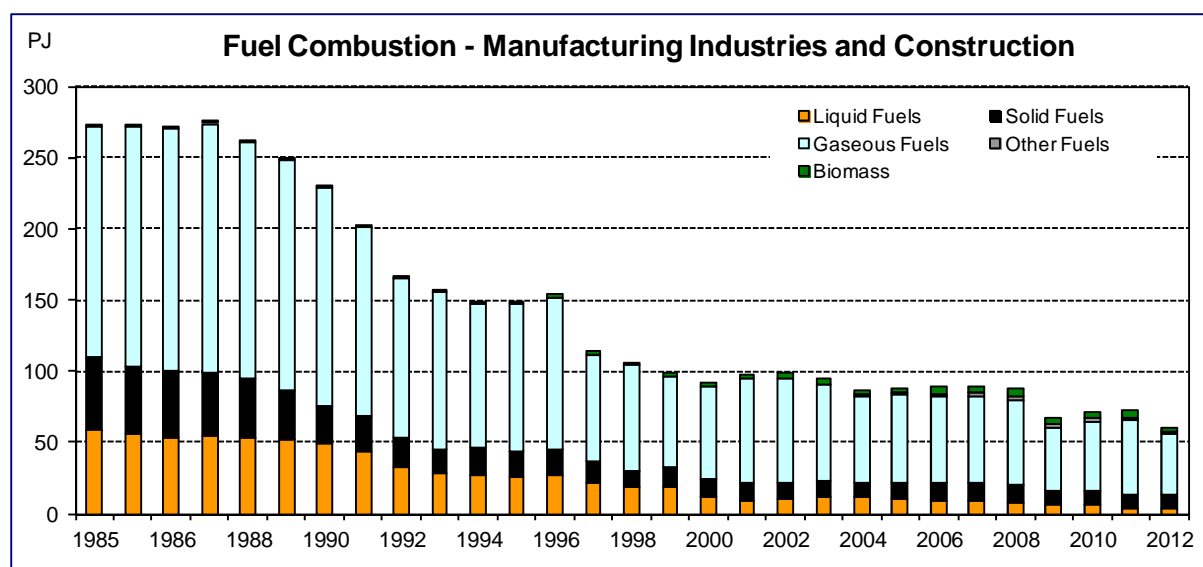
Part of the emissions from waste incineration for energy purposes was allocated to this source category. This was possible by using data from the Hungarian Waste Management

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 3.2.6.2. First, amount of waste had to be converted to energy units (or to be taken directly from the IEA Renewable questionnaire), 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 (mostly emission, partly fuel consumption) 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

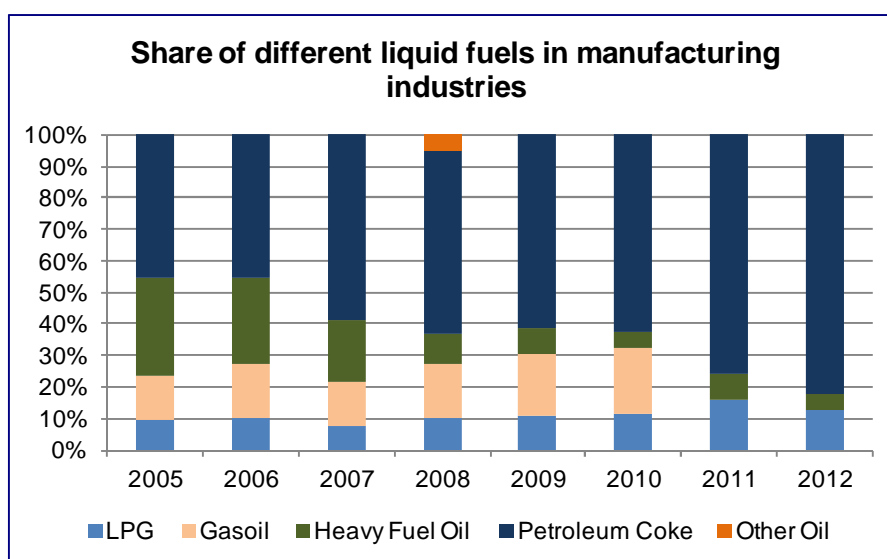
Figure 3.1.15 illustrates the energy consumption of the sector. After 1990, following the economic changes, fuel use has been significantly decreasing. The underlying reasons are clearly illustrated by the decreasing production data presented in the *Industrial Processes Sector (Chapter 4)*.



**Figure 3.1.15** Fuel combustion in the Manufacturing Industries and Construction Sector (1985-2012)

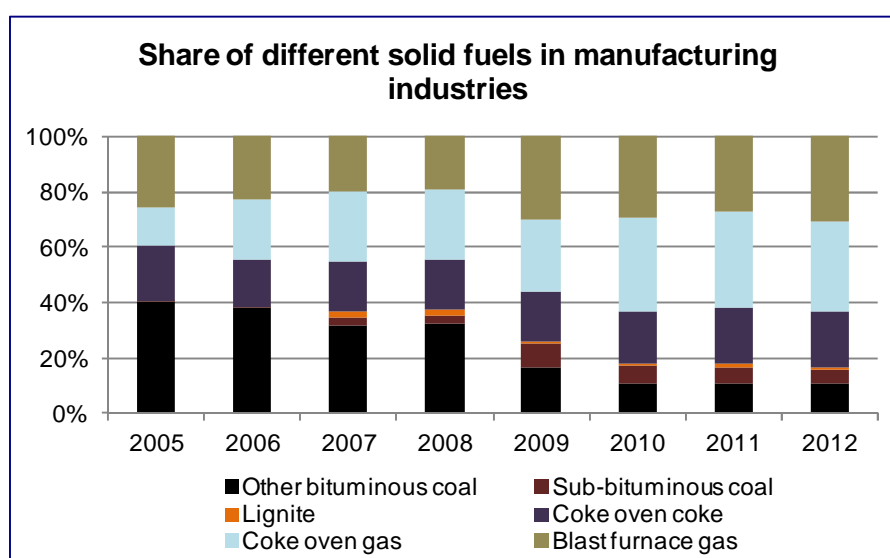
Compared to current level, the higher energy use of the industry around 2005 was linked to the growth of industrial production, namely a number of energy intensive sectors: manufacture of non-metallic mineral products, primarily glass, and chemical industry. Biomass use became popular especially in the last decade. 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 caused a drop of fuel consumption by more than 20% which led to lower emissions. In 2010, the growing industrial production increased the energy demand that did not change much either in 2011 or in 2012.

Fig. 3.1.15 clearly demonstrates the dominance of natural gas (71% in 2012). Liquid fuels represented only 6% in 2012 out of which petroleum coke use in non-metallic minerals seems to be the most important (see Fig. 3.1.16).



**Figure 3.1.16** Share of different liquid fuels used by manufacturing industries (2005-2012)

Overall, similarly to liquid fuels, the share of solid fuels has been quite low which is in a sharp contrast with the beginning of the time series. The fuel mix has been changing also as demonstrated by Fig. 3.1.17. The growing relative share of coke oven gas and blast furnace gas define the CO<sub>2</sub> IEF in the iron and steel category since coke oven gas has a very low (47.7 t/TJ) whereas blast furnace gas a quite high (250-260 t/TJ) CO<sub>2</sub> emission factor. 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 3.1.17** Share of different solid fuels used by manufacturing industries (2005-2012)

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 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 allocated under the *Industrial Processes Sector* since it was assumed that these fuels

served only as additives increasing the porosity of bricks. (But these are not significant amounts.)

Biomass cannot be considered as the most important fuel, its contribution was about 5-6 per cent. Within this, however, the growing share of biogases (especially in autoproducer plants) might deserve our attention as the default emission factors are quite different for solid biomass and biogas.

### *Emission factors*

Mainly default CO<sub>2</sub> factors are used in this sector with some exceptions regarding solid fuels. 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 112.0 t CO<sub>2</sub>/TJ in 2012 and the factory used an oxidation factor of 0.99. (It has to be noted, though, that most of the coke oven coke use was reallocated to the industrial processes sector.)

Country specific emission factors are used also in the non-metallic minerals category (based on ETS information). The situation is somewhat more complicated here as the cement factories often use mixed fuels. For this submission, new country specific CO<sub>2</sub> emission factors have been introduced for petroleum coke/coal mix varying between 92.4 t/TJ and 95.0 t/TJ for the period 2008-2012.

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 case of derived gases (coke oven gas, blast furnace gas) and biogases, the default emission factors were taken from the 2006 IPCC Guidelines.

### **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%.

### **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**

Beside switching to the IEA/Eurostat fuel consumption data, two important additional changes occurred:

- Reallocation of emissions from blast furnace gas from Industrial Processes to 1.A.2.a Iron and Steel. This represents about 700 Gg of additional CO<sub>2</sub> emissions in the first commitment period (+2,219 Gg in 1990 and +684 Gg in 2011);

- Introducing new country specific emission factors for a mixed fuel containing petroleum coke and different coal types.

#### **3.2.7.6 Source-specific planned improvements**

Besides moving toward the 2006 IPCC Guidelines, none.

### 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 sources:

Road transportation – Gasoline – CO<sub>2</sub>: L1, T1;

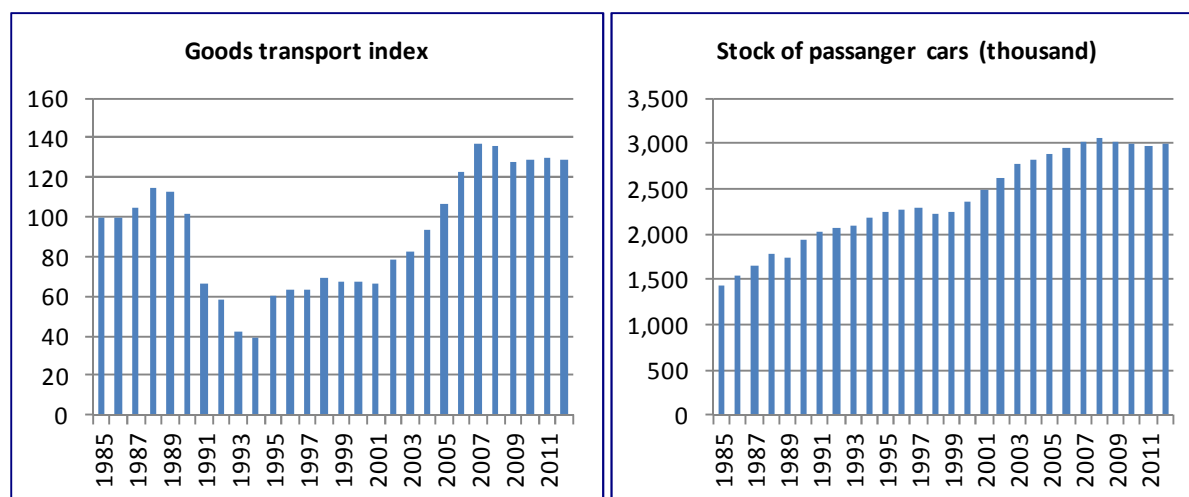
Road transportation – Diesel – CO<sub>2</sub>: L1, T1;

Other mobile combustion – Liquid – CO<sub>2</sub>: T1.

This sector covers all the emissions from fuels used for transportation purposes. International aviation is excluded from the national total.

Looking at the whole period of our time series, a sharp decrease of 60% in transport of goods could be observed during the regime change in the early 90's. The Hungarian transport performance expressed in freight tonkilometers had not reached the level of 1985 until 2005. Beside these significant changes of volume, also the structure of goods transport altered. Currently, the most important means of freight transport is road transportation with a share of 67%, followed by rail (18%), pipeline (11%) and waterway (4%). In 1990 we saw a completely different picture with railway and waterway being the dominant mode of transport representing 41% and 36%, respectively. The share of road transportation was 12% about 20 years ago.

Passenger transport also underwent considerable changes. The stock of passenger cars had more than doubled since 1985. Within this increase, the proportion of Eastern European cars characterized by high fuel consumption and obsolete technology decreased; currently, almost 90% of the vehicles are more advanced cars. *Figure 3.1.18* summarizes the above mentioned developments.



**Figure 3.1.18** General changes in the transport sector

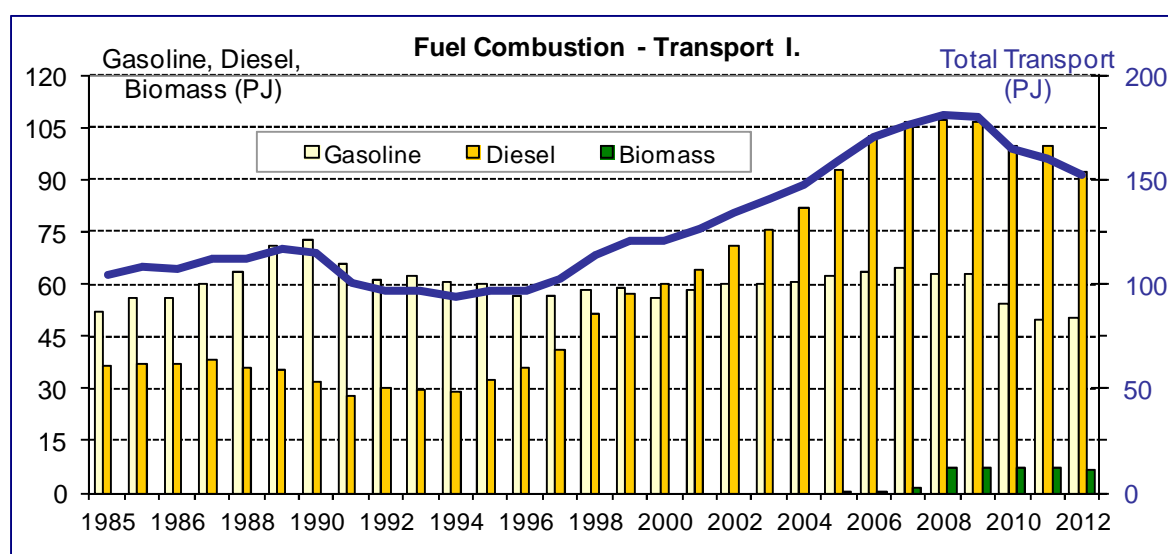
Electrification of the railways in Hungary decreased the solid fuel consumption by 99.5%. Today there are only few lines where steam engines are used during non-scheduled vintage train trips. Diesel oil consumption of railways decreased as well, by 75% between 1990 and 2012.

Emissions were calculated from the national fuel consumption data published in Energy Statistical Yearbook (1985-2010) and from IEA/Eurostat questionnaires.

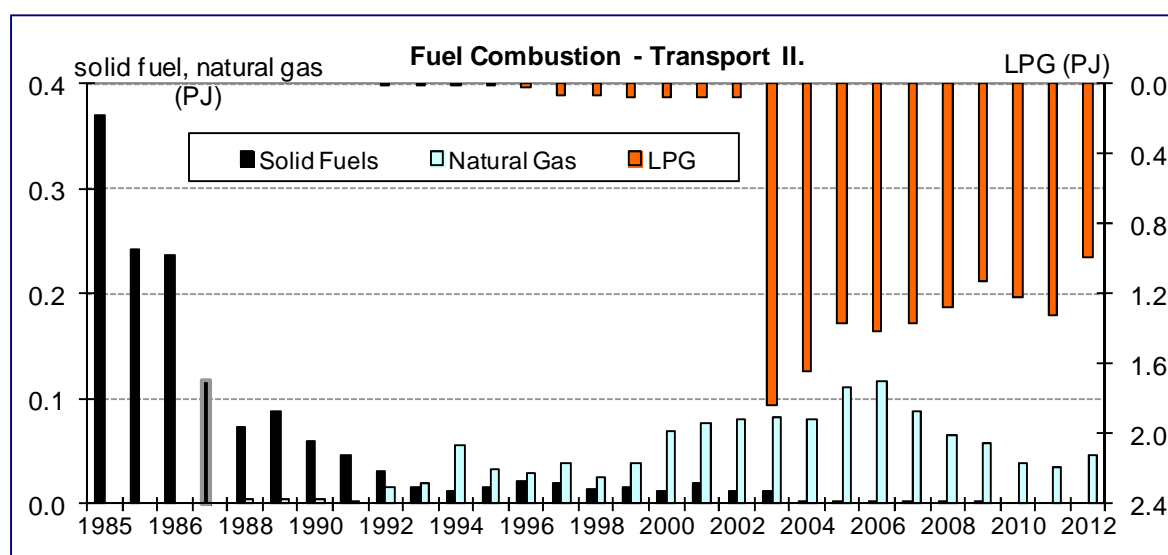
National statistics usually does not have separate lines for the quantities of aviation gasoline used for in-country aviation and of the diesel oil used for international (river) navigation (both represent negligible amounts in Hungary). Aviation gasoline consumption is included under road transport.

Based on information received from the energy statistics provider, natural gas use related to natural gas transport are included under distribution losses. (The resulting emissions are most probably included in Residential.) 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. We had six compressor stations in 2011 with 1.7 PJ natural gas consumption and 93 Gg CO<sub>2</sub> emission. In 2012, 2.1 PJ natural gas was used by six compressor stations that resulted in 121 Gg CO<sub>2</sub> emission.

Figures below illustrate fuel consumption of the sector:



**Figure 3.1.19** Gasoline, diesel and biomass consumption and total energy use in the Transport Sector (1985-2012)



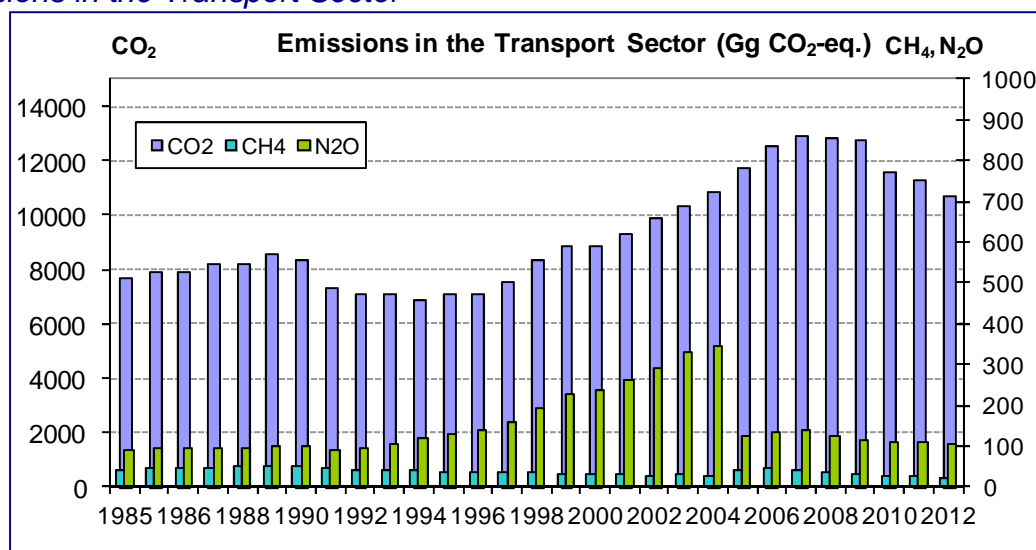
**Figure 3.1.20** LPG, natural gas and solid fuel combustion in the Transport Sector (1985-2012)

Figure 3.1.19 clearly shows that in contrast to the other described sectors, transport consumption had 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 appear also in *Fig. 3.1.19*.

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 use by the general public (currently including LPG only) shows a significant drop in the same period..

### *Emissions in the Transport Sector*



**Figure 3.1.21** Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Transport Sector (1985-2011)

### **3.2.8.2 Methodological issues**

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

In 2013, as the compiler institute received data on carbon content of gasoline and diesel oil from the refinery, the default emission factors were replaced to country specific values in *road transportation*.

Calculation of CH<sub>4</sub> and N<sub>2</sub>O emissions from road transport was changed a few years ago in line with the ERT's recommendation 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. 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, it was assumed that real catalyst vehicle has been used after this time.

As we received the COPERT outputs run by KTI for the years 2006, 2007, 2009, 2011, and 2012, new CH<sub>4</sub> and N<sub>2</sub>O estimates have been included in this submission for the period 2005-2012. (See for details in Annex A3.1.) For the five years for which we had direct model outputs, these outputs were used without modification. For the years in-between, i.e. for 2008 and 2010, the average of implied emission factors from neighboring years was applied.

For 2005, the same IEF was used as in 2006.

Thus, two different approaches have been applied in the time series: the domestic method for the period 1985-2004 and the COPERT model for 2005-2012.

The main differences between these approaches are as follows:

- Both methods use basically the same fleet stock numbers but there are differences in the categorization of vehicles. In our domestic approach, we defined seven types of passenger cars with gasoline engines and only one for diesel cars. In the COPERT database, there are 22 types of passenger cars with gasoline engines including hybrid and 2-stroke), and 12 types of diesel cars. (However, as the CH<sub>4</sub> and N<sub>2</sub>O emission factors seem to be independent from the size of the car, this difference in the number of types is more relevant to diesel cars). The Hungarian COPERT database contains more vehicle types also in any other categories (LDV, HDV, motorcycles, buses).
- In the domestic method more or less the stock of the different vehicle types and their average fuel consumption defines their share in the total fuel consumption. (The only exceptions are with some obsolete technologies, such as 2-stroke, non-oxidation catalyst, and uncontrolled, where a real use factor was introduced to reflect the diminishing mileage of older cars. This factor had a value of 1.0 until 1993, and then it was gradually reduced to 0.4 in the period 1994-2008.) In the COPERT model different mileage expressed in km/year is allocated to all vehicle types which probably reflects real share in total fuel consumption in a more reliable way.
- Despite of different units in the applied domestic method based on IPCC Guidelines (kg/TJ) and in COPERT (g/km) we have tried to compare the emission factors. Our first analysis indicate the following main differences:
  - Gasoline CH<sub>4</sub> factors for PRE ECE and 2-stroke seem to be quite similar, however from Euro 1 COPERT has higher emission factors, and for Euro 4 and 5 we see a three times higher EF. COPERT has higher EF also for buses (+67%). In contrast, EFs for diesel engines are usually lower in COPERT: the difference is 46% for passenger cars, and between 28% and 78% for duty vehicles.
  - N<sub>2</sub>O emission factors are generally lower in COPERT for most passenger cars with gasoline engine (-27% for PRE ECE, and -90% for Euro 5) and for diesel duty vehicles and buses (from -58% to -66%). For diesel cars, however, COPERT has larger N<sub>2</sub>O EF by 20% on average, and the difference is even higher for 2-stroke passenger cars (+77%).

### *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 3.1.11** CO<sub>2</sub> emission factors in the Transport Sector

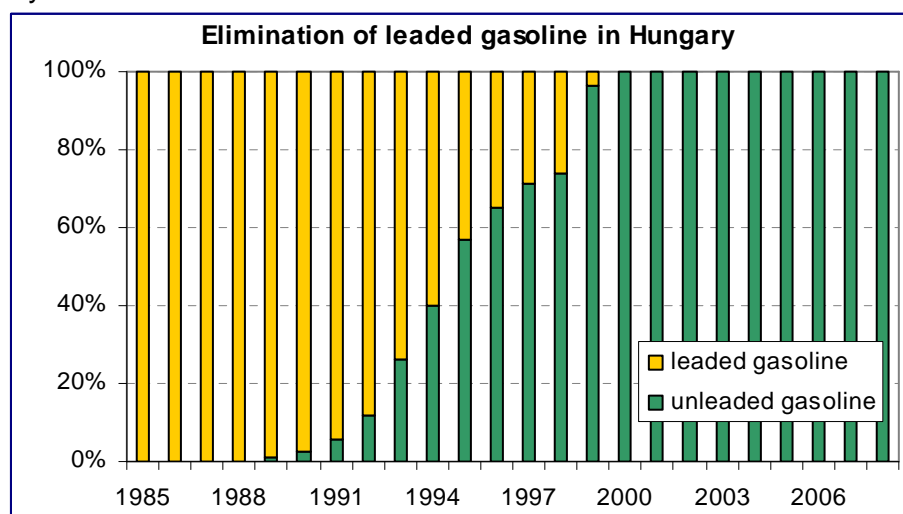
Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
Liquid fuels	Gasoline	18.9	Revised 1996 Guidelines, Table 1-2
	<i>in road transport</i>	<b>19.8</b>	Refinery
	Gas/Diesel Oil	20.2	Revised 1996 Guidelines, Table 1-2
	<i>in road transport</i>	<b>20.3</b>	Refinery

Category	Fuel type	Emission factor (t C/TJ)	Source of EFs
	LPG	17.2	Revised 1996 Guidelines, Table 1-2
	Residual fuel oil	21.1	Revised 1996 Guidelines, Table 1-2
Solid fuels	Brown Coal	26.2	Revised 1996 Guidelines, Table 1-2
Gaseous fuels	Natural Gas	15.3	Revised 1996 Guidelines, Table 1-2

It has to be noted that the cited CO<sub>2</sub> emission factors in the above table are somewhat arbitrary, because the used activity data for emission calculations are gasoline and diesel oil consumption expressed in kilotonnes and not in terajoules. The net calorific value applied in the Hungarian energy statistics is usually 42 TJ/kt for both fuels. We kept this figure in the inventory. However, there are indications that the real calorific value might be different. For example, the default NCVs are 43.8 TJ/kt for gasoline and 42.7 TJ/kt for diesel in COPERT. In the 2006 IPCC Guidelines we can find even higher values: 44.3 TJ/kt and 43 TJ/kt for gasoline and diesel, respectively. And we have also one measurement from the refinery for diesel oil, which is 43.04 MJ/kg. Therefore there might be some smaller change in the reported activity data for transport, i.e. fuel consumption in TJ, but that would not change the emissions because these are based on kilotonnes of fuels. The used emission factors were 84.06 t C / t gasoline and 86.275 t C / t diesel, and a default oxidation factor of 0.99 was applied.

As discussed above, CH<sub>4</sub> and N<sub>2</sub>O emissions were calculated using the COPERT model (COPERT 4, version 9.0) for the period 2005-2012. For the earlier years, 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 3.1.22** Elimination of leaded gasoline in Hungary

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

Methane and nitrous oxide emission factors for road transport used for the period 1985-2004 are summarized in Table 3.1.12.

**Table 3.1.12** 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		50.0	0,1	9.0	EF: Revised 1996 IPCC Guidelines; 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

	<b>Bus</b>	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*

Table 3.1.13 gives an overview of the emission factors used for railways and navigation.

**Table 3.1.13** 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)

Emissions from in-country aviation, which represent a very low proportion, were taken previously 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.

Although there are no scheduled commercial domestic flights in Hungary, Eurocontrol data for 2012 suggested that 0.3 per cent of total jet kerosene is used for domestic flights. Using the same share back to 1985, some kerosene use is now allocated to domestic aviation. The resulting CO<sub>2</sub> emission is 1.4 Gg on average.

### 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%).

Because of the different approaches used for non-CO<sub>2</sub> emissions in road transportation, the time series is not completely consistent.

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

IEA data were compared with the national statistics. For clarification of the differences, additional data were required from the energy statistics provider. This led to revision of the time series of fuel consumption.

We consider the technical review of the EU as a very important QA activity. In summer 2012, the EU conducted a more thorough than usual review of the inventories of all member states. After the review, Hungary was recommended to obtain the C content and net calorific values

of gasoline from fuel suppliers, to develop a country-specific EF for CO<sub>2</sub> from gasoline that is representative for gasoline used in Hungary and to revise data accordingly.

### 3.2.8.5 Source-specific recalculations

As described above, 0.3 per cent of total jet kerosene use is allocated to domestic aviation. The resulting changes are summarized in the table below.

**Table 3.1.14** *Added kerosene use in domestic aviation*

	OLD TJ	NEW TJ	NEW CO <sub>2</sub>
1985	NO	15.6	1.1
1985-87	NO	15.6	1.1
1986	NO	15.8	1.1
1987	NO	15.4	1.1
1988	NO	15.6	1.1
1989	NO	16.3	1.2
1990	NO	17.3	1.2
1991	NO	13.6	1.0
1992	NO	14.4	1.0
1993	NO	13.2	0.9
1994	NO	19.9	1.4
1995	NO	19.1	1.4
1996	NO	20.3	1.4
1997	NO	19.3	1.4
1998	NO	20.2	1.4
1999	NO	21.7	1.5
2000	NO	24.2	1.7
2001	NO	22.9	1.6
2002	NO	21.6	1.5
2003	NO	21.1	1.5
2004	NO	24.3	1.7
2005	NO	28.2	2.0
2006	NO	28.5	2.0
2007	NO	26.1	1.8
2008	NO	29.0	2.1
2009	NO	24.8	1.8
2010	NO	24.7	1.7
2011	NO	24.8	1.8
AVG			1.4

For LPG use in road transportation, the emission factors taken from the 2006 IPCC Guidelines are used consistently for the whole time series.

### 3.2.8.6 Source-specific planned improvements

It is planned to increase the consistency of the time series of non-CO<sub>2</sub> emissions in road transportation.

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

#### 3.2.9.1 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 sources:

Stationary combustion - Other – Gas - CO<sub>2</sub>: L1, T1;

Stationary combustion - Other – Liquid - CO<sub>2</sub>: L1, T1;

Stationary combustion - Other – Solid - CO<sub>2</sub>: T1

Stationary combustion - Other – Solid – CH<sub>4</sub>: L1, T1

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

#### Emissions in the Other Sector

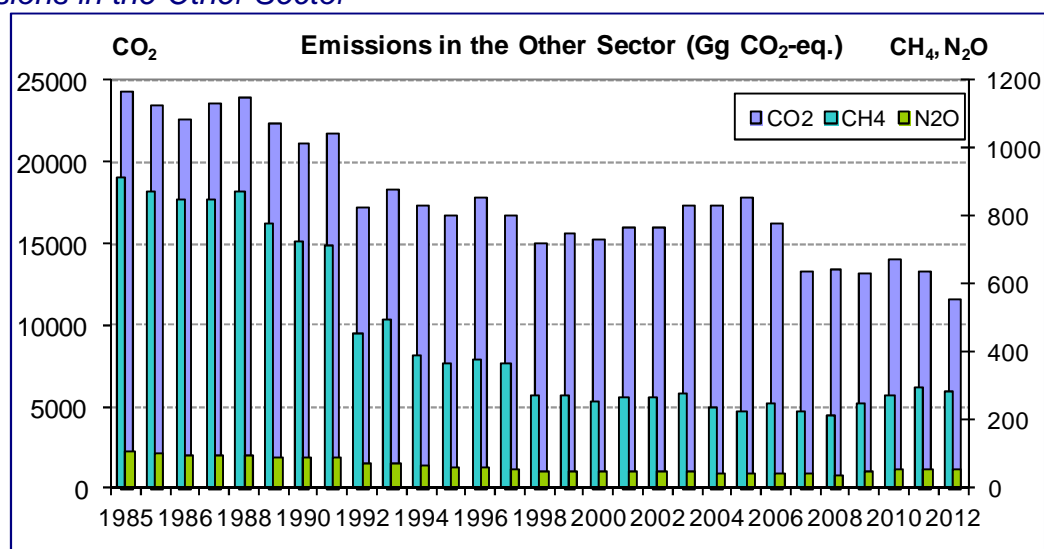
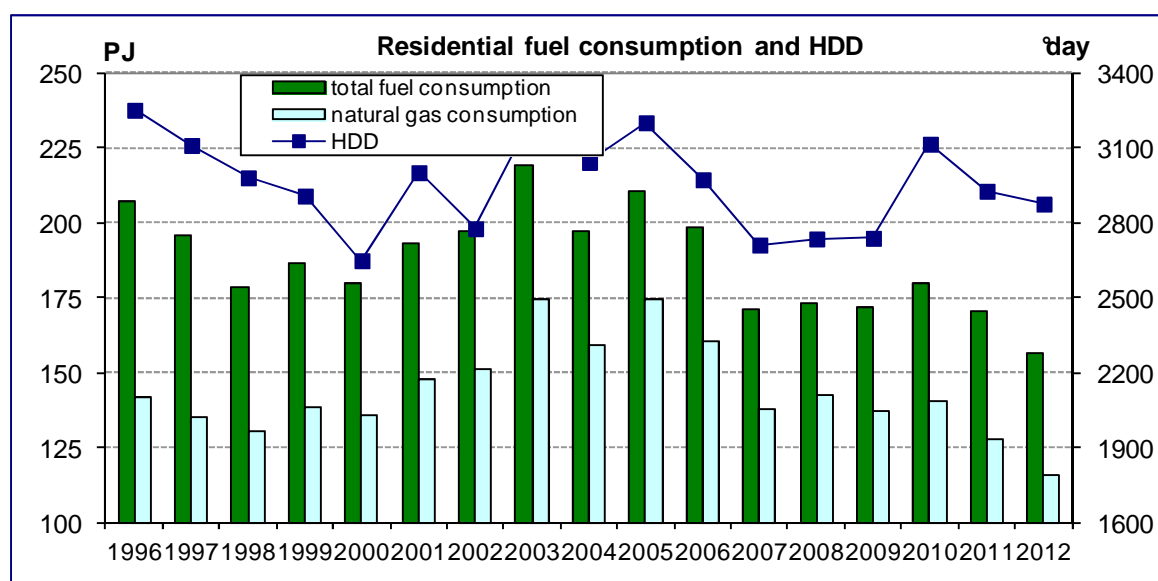


Figure 3.1.23 Trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions in the Other Sector (1985-2012)

#### HDD and energy demand of the Residential Sector

Heating degree day (HDD) is a quantitative index that reflects demand for energy to heat houses and businesses. This index is derived from daily temperature observations. The inside temperature is 18°C and base temperature (the outside temperature above which a building needs no heating) is 15°C in our calculation (following the standard European methodology). Figure 3.1.24 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.

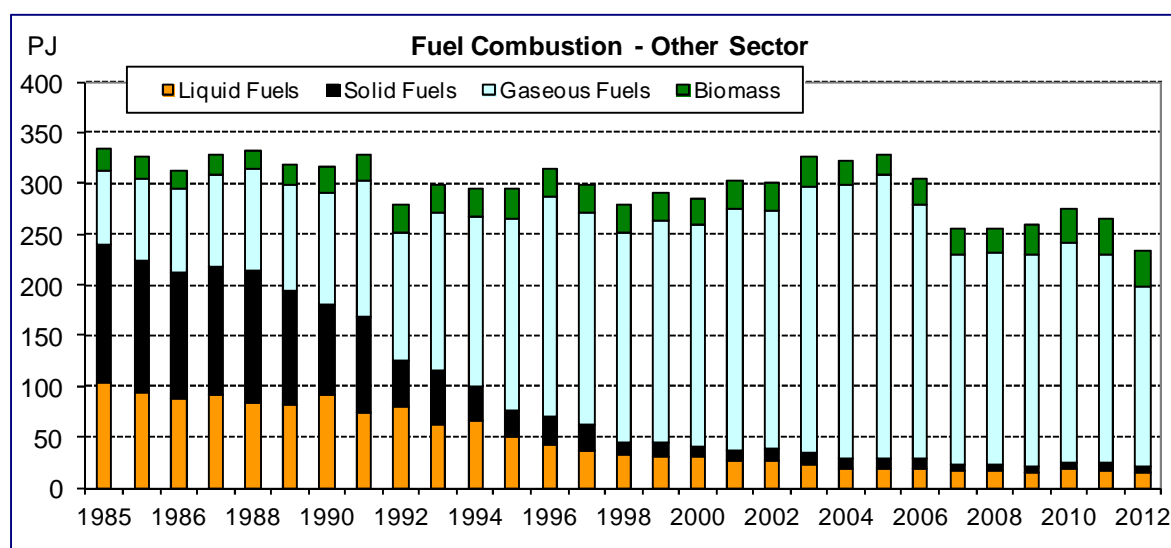


**Figure 3.1.24** Comparison of residential fuel consumption and HDD between 1996 and 2012

### 3.2.9.2 Methodological issues

#### Activity data

Activity data was obtained from the IEA/Eurostat questionnaires as described in the introduction section of the chapter. *Figure 3.1.25* illustrates the fuel consumption of the sector by types.



**Figure 3.1.25** Share of different combusted fuel types in the Other Sector (1985-2012)

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 3.1.25* above. During the period 1985-2012 natural gas transmission pipelines length had increased from 3544 km to 5784 km. The number of households supplied with natural gas has been increasing continuously, even in the last decade from 2.8 to 3.3 million. Population switched from coal to natural gas combustion. Household heating

oil was completely replaced by LPG.

**Table 3.1.15** Oil and LPG consumption in the Commercial/Institutional and Residential Sectors in selected years after 2000

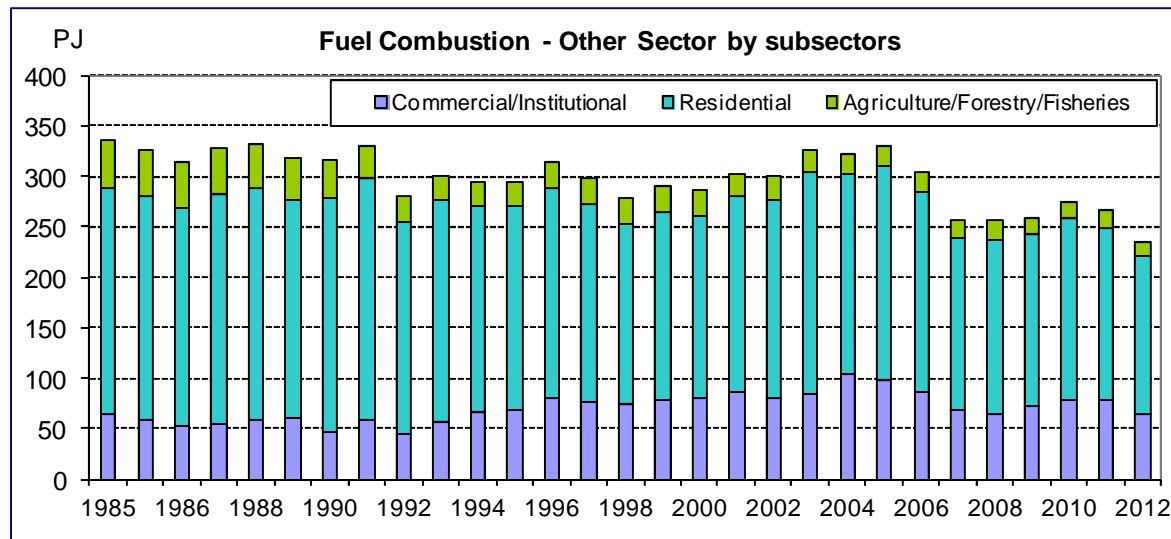
Sector	Fuel consumption (TJ)	2000	2004	2005	2008	2009	2010	2011	2012
Commercial/Institutional	Oil	1,246	373	373	0	0	0	0	241
	LPG	2,209	987	1,081	799	799	893	752	705
Residential	Oil	1,092	378	84	0	0	0	0	0
	LPG	12,079	7,144	7,802	4,418	4,465	5,640	4,935	4,183

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, 2012).

Residential consumption represented 34% of total piped gas supply in 2012. Piped gas is available in 91% of all settlements in Hungary. Some 84% 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.

Steadily rising tariffs and the economic crisis were the main reasons of growing biomass use in this sector. In 2012, the share of biomass was 15 per cent. In Agriculture category the significant growth in biogas use might deserve our attention as its share within biomass reached 22 per cent.

The consumption rates of the subsectors are shown in *Figure 3.1.26*.



**Figure 3.1.26** Fuel combustion in the subsector of the Other Sector (1985-2012)

### *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 under Energy Industries, because power plants that report measured carbon content of lignite, sell directly to residential consumers, too.

Since the entire quantity of liquid fuels used in residential combustion is LPG and the majority of institutional uses are also based on LPG, the IEF factor for CO<sub>2</sub> is very low.

Default emission factors for CH<sub>4</sub> taken from Table I-7 of the 1996 IPCC Guidelines are used. The only exception is biogas for which the default value from the 2006 IPCC Guidelines is applied. Similarly, default values from Table I-8 are used for N<sub>2</sub>O emission calculations with an exception for biogas.

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

We assume that the uncertainty of the fuel consumption data of the *Other Sector* is higher than in case of industrial processes because such data are more difficult to collect and verify. Considering the above, the estimated uncertainty of the energy consumption data is less than ±10%. The estimated uncertainty of the emission factors for CH<sub>4</sub> is moderate (±30% to 35%), whereas that of N<sub>2</sub>O may be very high, i.e., 50% to 100%, as mentioned above.

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

Comparing residential coal consumption data in the Hungarian Energy Statistical Yearbook and the IEA/Eurostat statistics, large discrepancies in NCV were found for the years before 1999. After discussing this issue with the energy statistics provider, the higher values from the domestic publication were kept.

### **3.2.9.5 Source-specific recalculations**

Except for using the IEA/Eurostat fuel consumption data, none.

### **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 still 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*).

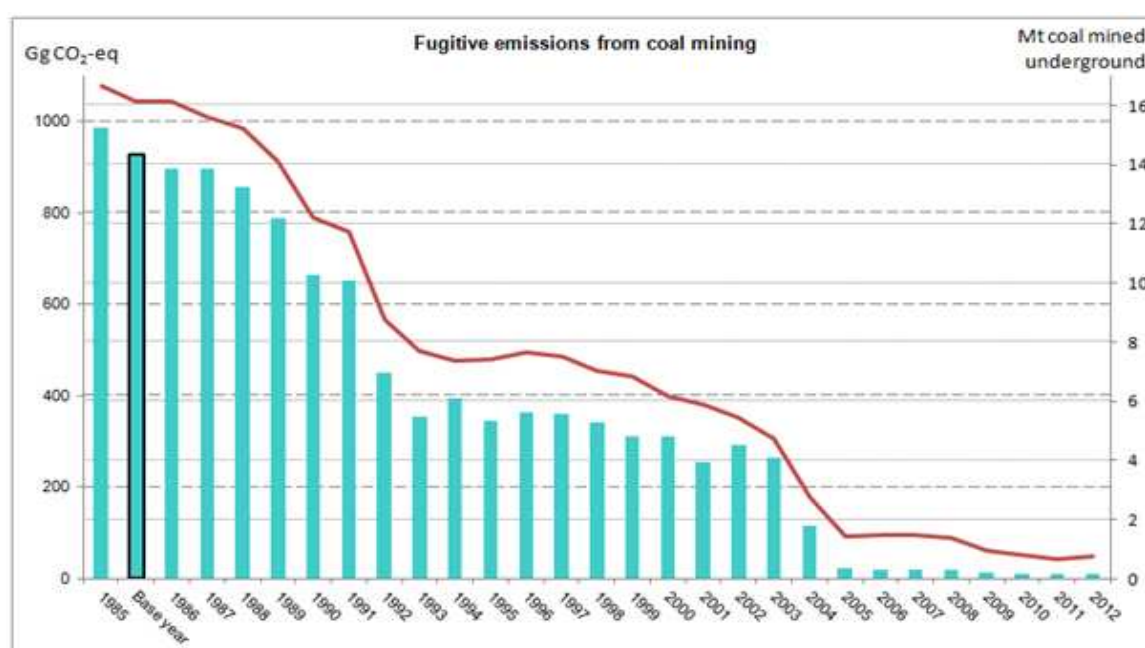
Emissions from category 1B1b – Fugitive emissions originating from solid fuel transformation are included in sector 1A1c. The reason is that it is not possible to separate the GHG

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 3.2.2*).

Please note, that the coal classification in the figures and tables within this subchapter represent the "old" coal classification of the Hungary. As it is described in chapter 3.2.1 and in Table 3.1.1, lignite and brown coal mined in Hungary are classified as lignite in IPCC (and IEA) coal classification and hard coal (mined solely until the beginning of 1990s) is classified as sub-bituminous coal in IPCC terminology. The different classification of coal does not influence the calculation of emissions, as emissions are calculated based on country specific data from the Hungarian mines.

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 3.2.1* resulted in decreasing trend of emissions.



**Figure 3.2.1** Trends of emissions from solid fuels (1985-2012)

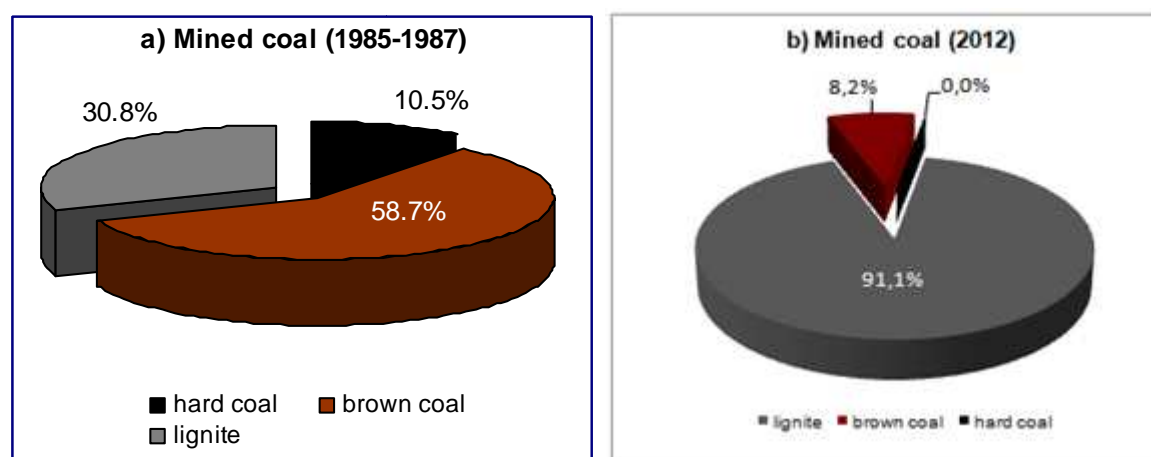
In 2014 submission in subsector 1.B.1.b Fugitive emissions from solid fuel transformation notation key of activity data has been changed from NO to IE as required by 2013 review in order to reach consistency with notation key of emissions. IE notation key is applied because emissions from solid fuel transformation are included in 1.A.1.c Manufacture of solid fuels.

### 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 3.2.2** Distribution of mined coal in the base year (a) and 2012 (b)

**Table 3.2.1** Underground and surface coal mining in Hungary 1985-2012

	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	2002
Surface mining (Mt coal)	6.890	6.730	7.150	7.536	8.081	7.610	7.696	7.873	8.043	7.574
Underground mining (Mt coal)	7.720	7.380	7.438	7.654	7.508	7.040	6.851	6.160	5.871	5.453
Total indigenous production - Coal (Mt)	14.610	14.110	14.588	15.190	15.589	14.650	14.547	14.033	13.914	13.027
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Surface mining (Mt coal)	8.564	8.470	8.154	8.467	8.352	8.041	8.027	8.301	8.893	8.534
Underground mining (Mt coal)	4.737	2.772	1.416	1.485	1.466	1.363	0.959	0.812	0.665	0.763
Total indigenous production - Coal (Mt)	13.301	11.242	9.570	9.952	9.818	9.404	8.986	9.113	9.558	9.297

Table 3.2.1 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.

To the best of our knowledge, Hungarian mines are not drained nowadays and 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 gobbled 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.

In 1.B.1.a Coal mining sector CO<sub>2</sub> emissions are reported from CH<sub>4</sub> recovery for the years 1985-1996. In this case CO<sub>2</sub> emissions are not direct emissions, but it is calculated from the

amount of recovered CH<sub>4</sub> (CH<sub>4</sub> burned for energy use) as follows:

$$\text{CO}_2 \text{ emissions} = (\text{Recovered CH}_4) * 44/16$$

(M<sub>CO<sub>2</sub></sub>= 44 g/mol; M<sub>CH<sub>4</sub></sub>= 16 g/mol)

The yearly amount of recovered CH<sub>4</sub> and the stop of the recovery (due to the closure of the mines) were communicated by the Hungarian Office for Mining (Mining Bureau of Hungary).

#### *Emission factors*

Emission factors are based on 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 3.2.2 shows the measured methane content of coal for the mines operating between 1985 and 2005 in Hungary. The data on in-situ methane content of the mines originates from research project conducted by Regional Centre for Energy Policy Research (available at: <http://www.rekk.eu/images/stories/letoltheto/uhg-ag-vol2.pdf>) included in list of References. In addition in-situ gas content (quantity and composition) is measured in the one single underground coal mine still working in Hungary. The results are published in USGS, 2002. (please see the Reference list). The measured data is in accordance with the classification of mines regarding risk of firedamp received every year from the Hungarian Mining Authority, which is also based on the m<sup>3</sup> methane/ t coal value. In addition the emission factors used are mainly within the range of IPCC default factors as it is presented in Table 3.2.3.

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 3.2.2 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 3.2.2 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 3.2.3, 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 3.2.3** 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 review in 2012, 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%.

Please find the presently available uncertainty values based on expert judgment in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply.

### 3.3.1.5 Source-specific recalculations

None.

### 3.3.1.6 Source-specific planned improvements

Application of 2006 IPCC Guidelines.

## 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

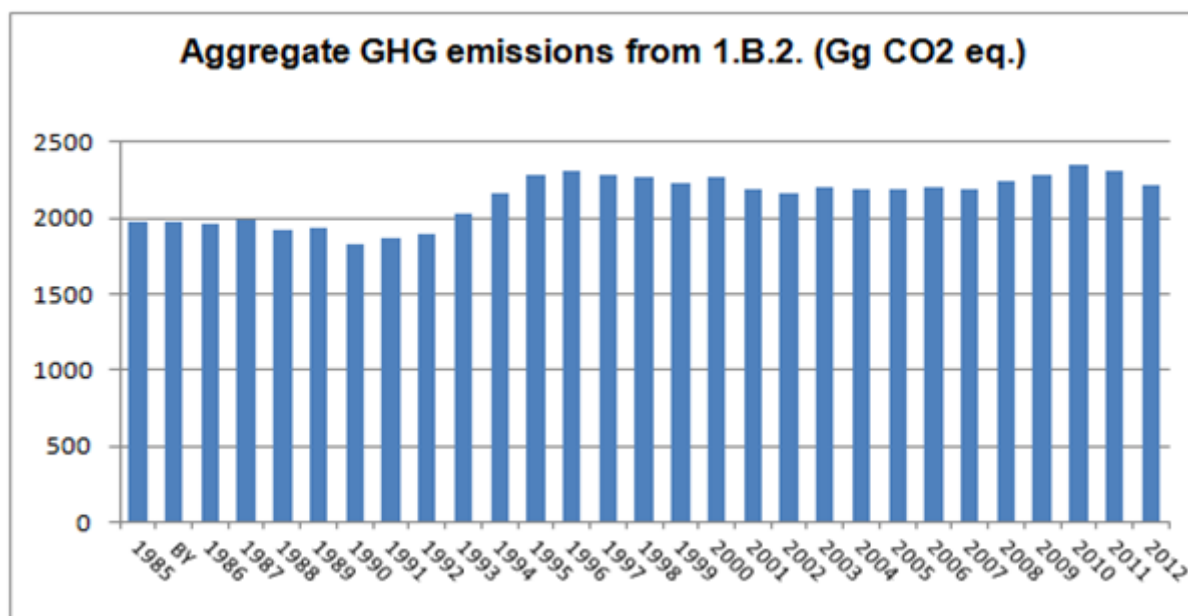
Emission factors: D, CS, OTH

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 consumption significantly increased compared to the 1980s but the demand is mainly covered by import.



**Figure 3.2.3** Trends of emissions in CO<sub>2</sub> eq from oil and natural gas activities (1985-2012)

### 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 in 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.

Since the 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 the 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 both fugitive and flaring categories is 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 2013 submission, completeness was further improved by including estimation of emissions from oil refinery flaring for the years before 2005 as well. In category *1B2c-Venting and flaring of oil and natural gas*, Hungary has reported CO<sub>2</sub> emissions from oil refinery flaring since the 2009 submission in addition to gas and oil production/processing venting and flaring emissions. The latter emissions are reported using default emission factors from GPG2000 and oil refinery flaring CO<sub>2</sub> emissions were taken from EU ETS annual emission reports since 2005 due to lack of emission factors in the Guidebooks. In this year oil refinery flaring EU ETS data of an additional oil refinery in Hungary was included and oil refinery flaring data was extrapolated for the years before 2005 using the amount of “Refinery intake” as surrogate data. In this way full coverage and consistency within the time-series has been reached. Please see details and comparison Table of this recalculation in chapter 3.3.2.5 below and in chapter 10.1.

Emissions of indirect GHGs have also been recalculated using EMEP/EEA Guidebook 2009 emission factors. In addition to indirect emissions from oil refinery flaring reported, also indirect GHG emissions from further subsectors (exploration, production, processing, transmission, distribution, venting and flaring for both oil and natural gas) have been included in 2013 submission. In this way the reporting has become consistent with CLRTAP reporting of Hungary.

In 2014 submission, CO<sub>2</sub> emission in 1B2b3 is included based on GPG Table 2.16 T1 emission factor. With the inclusion of some other missing estimation, the application of T1 factors from the GPG Table 2.16 are now complete. The recalculation resulted in less than 1 Gg increase of emission of CO<sub>2</sub> in sector 1.B.2.

The complete list of emission factors used in category 1.B.2 is presented in *Table 3.2.4*.

**Table 3.2.4** Default emission factors used in 1B2

IPCC subsector code	Oil 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)	$4.3 \cdot 10^{-7}$	$2.8 \cdot 10^{-8}$	NA	IPCC - Background Papers, 2002 and GPG2000
	Wells – Testing (number)	$2.7 \cdot 10^{-4}$	$5.7 \cdot 10^{-3}$	NE	IPCC - Background Papers, 2002 and GPG2000
	Wells – Servicing, (number)	$6.4 \cdot 10^{-5}$	$4.8 \cdot 10^{-7}$	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.a.ii	Oil Production – Conventional ( $10^6 \text{ m}^3$ )	$1.8 \cdot 10^{-3}$	$2.7 \cdot 10^{-4}$	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.a.iii	Oil Transport – Pipelines ( $10^9 \text{ m}^3$ )	$5.4 \cdot 10^{-6}$	$4.9 \cdot 10^{-7}$	NA	IPCC - Background Papers, 2002 and GPG2000
	Oil Transport – Tanker Trucks and Rail Cars ( $10^6 \text{ m}^3$ )	$2.5 \cdot 10^{-5}$	$2.3 \cdot 10^{-6}$	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 ( $10^9 \text{ m}^3$ )	$3.1 \cdot 10^{-3}$	$9.5 \cdot 10^{-5}$	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Sweet Gas Plants ( $10^6 \text{ m}^3$ )	$7.1 \cdot 10^{-4}$	$2.7 \cdot 10^{-5}$	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Sour Gas Plants ( $10^6 \text{ m}^3$ )	$2.4 \cdot 10^{-4}$	$2.9 \cdot 10^{-5}$	NA	IPCC - Background Papers, 2002 and GPG2000
	Gas Processing – Deep-cut Extraction Plants ( $10^6 \text{ m}^3$ )	$7.2 \cdot 10^{-5}$	$3.0 \cdot 10^{-7}$	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.b.iii	Gas Transmission (km)	$3.4 \cdot 10^{-3}$	$1.6 \cdot 10^{-5}$	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 and LPG and Condensates and Pentanes Plus transport ( $10^6 \text{ m}^3$ )	$1.1 \cdot 10^{-4}$	$4.3 \cdot 10^{-4}$ ; $7.2 \cdot 10^{-6}$	NA	IPCC - Background Papers, 2002 and GPG2000
1.B.2.c.1.1	Oil Production Venting	2000 kg / PJ Oil Produced	$1.2 \cdot 10^{-8}$ Gg / Oil Production Conventional ( $10^6 \text{ m}^3$ )	NA	IPCC1996 , GPG2000

1.B.2.c.1.2	<b>Gas Production&amp;Processing Venting</b>	24000 kg/ PJ Natural Gas Produced	$7.1 \cdot 10^{-2}$ Raw CO <sub>2</sub> venting - Sour Gas Plants (106m <sup>3</sup> ) reported in 1.B.2.b.ii.	NA	IPCC1996, IPCC - Background Papers, 2002 and GPG2000
1.B.2.c.1.2	<b>Gas Transmission Venting – Gas Transmission (km)</b>	included in 1.B.2.b.iv. Gas transmission	$8.5 \cdot 10^{-8}$	NA	GPG2000
1.B.2.c.2.1	<b>Oil Refinery flaring</b>	NA	EU ETS data	NA	CS
	<b>Oil Production flaring– Conventional (10<sup>6</sup>m<sup>3</sup>)</b>	$2.5 \cdot 10^{-5}$	$6.7 \cdot 10^{-2}$	$6.4 \cdot 10^{-7}$	GPG 2000
1.B.2.c.2.2.	<b>Gas Production flaring (10<sup>6</sup>m<sup>3</sup>)</b>	$1.1 \cdot 10^{-5}$	$1.8 \cdot 10^{-3}$	$2.1 \cdot 10^{-8}$	GPG 2000
	<b>Gas Processing flaring – Sweet Gas Plants (10<sup>6</sup>m<sup>3</sup>)</b>	$1.3 \cdot 10^{-5}$	$2.1 \cdot 10^{-3}$	$2.5 \cdot 10^{-8}$	GPG 2000
	<b>Gas Processing flaring – Sour Gas Plants (10<sup>6</sup>m<sup>3</sup>)</b>	$2.9 \cdot 10^{-5}$	$4.6 \cdot 10^{-3}$	$5.4 \cdot 10^{-8}$	GPG 2000
	<b>Gas Processing flaring – Deep- cut Extraction Plants (10<sup>6</sup>m<sup>3</sup>)</b>	$6.2 \cdot 10^{-6}$	$9.7 \cdot 10^{-4}$	$1.2 \cdot 10^{-8}$	GPG 2000
1.B.2.d	<b>Gas Storage (10<sup>6</sup>m<sup>3</sup>)</b>	$8.4 \cdot 10^{-4}$	NA	NA	GPG 2000

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 3.2.5.

**Table 3.2.5** Annual data for natural gas pipeline lengths in selected years

Pipeline length (km)											
Year	1985	1987	1990	1995	2000	2005	2008	2009	2010	2011	2012
<b>Transmission</b>	3544	3889	4046	4684	5767	5193	5300	5564	5782	5784	5784
<b>Distribution</b>	10262	14200	22559	53436	72540	80519	82128	82565	82884	83141	83141

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.

In subsector 1.B.2.a.i. Oil exploration, an error in the comment of IE notation key has been corrected (IE to 1.B.2.b.i. and to 1.B.2.C.2.1.) as required by 2013 review.

As required by 2013 review and provisional main findings, notation key of subsector 1.B.2.b „Other leakage” is also corrected from „NO” to „IE” (IE to 1.B.2.b. iv-v. Natural Gas Transmission and Distribution). The justification for the notation key is that HU uses T1 emission factors from the GPG for estimation of emissions in 1.B.2.sectors. Although IPCC1996 Table 1-58 does contain emission factors for "other leakage", it is based on the amount of natural gas consumed (PJ). While GPG Table 2.16. does contain T1 EF based on length of pipelines and does not contain emission factor separated for „Other leakage”. We assume that the EFs of GPG does contain emissions from „other leakage” as well, since GPG chapter 2.7.1.2. states:

*„ ... the new factors allow for improved correlation of emissions with commonly-available activity data, and may be expected to limit uncertainties to within an order of magnitude. The improved correlations are achieved through increased disaggregation of the industry and, in several cases, by switching to different activity parameters. For example, **fugitive emissions from gas transmission and distribution systems do not correlate well with throughput, and are better related to lengths of pipeline.**”*

### 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. Please find the presently available uncertainty values based on expert judgment in TableA7-1 in Annex 7 of the NIR.

In 2013 submission in 1.B.2.C.2.1 category full coverage and consistency within the time-series has been reached as in this year oil refinery flaring data was extrapolated for the years before 2005 using the amount of “Refinery intake” as surrogate data.

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

General QA/QC procedures apply. Plant specific data is verified with data in IEA Energy Statistics or with data received from the Hungarian Mining Authority where appropriate.

### 3.3.2.5 Source-specific recalculations

Time series have been recalculated due to the inclusion of further T1 emission factors for GPG for CO<sub>2</sub>. The recalculation resulted less than 1 Gg increase of emission of CO<sub>2</sub> in sector 1.B.2. Comparison Table of old and new time series are included in NIR chapter 10.

### 3.3.2.6 Source-specific planned improvements

Application of 2006 IPCC Guidelines.

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

### 3.3.3.1 Source category description

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

Methods: CS

Emission factors: OTH, CS

Key source: CH<sub>4</sub> Level and Trend in Tier 1 analysis

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 3.2.4 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 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 2000-2011.

### **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. Please find the presently available uncertainty values based on expert judgment in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply.

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

None.

### **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.

IEA/Eurostat: Annual Questionnaires (2014)

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/>

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-bqp.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.

Hungarian Central Statistical Office (HCSO), 2012: Statistical yearbook of Hungary (In Hungarian: Magyar statisztikai évkönyv, 2012), Budapest.

Hungarian Central Statistical Office (HCSO), 2013: Infrastructural supply of settlements, 2012 (In Hungarian: A települések infrastrukturális ellátottsága, 2012). Statisztikai tükör, VII., No. 87.

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.

Institute for Transport Sciences Nonprofit Ltd. (2012): Determining the road, railway, airway and water transport emissions in Hungary for the year 2011 – Final Report

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. . (<http://www.rekk.eu/images/stories/letoltheto/uhg-ag-vol2.pdf> )

USGS, 2002: Coalbed Gas in Hungary—A Preliminary Report By E.R. Landis, T.J.Rohrbacher, and C.E. Barker, U.S. Geological Survey and B. Fodor and G. Gombár, Hungarian Geological Survey, Minerals Management Division

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.)

### Recent key developments:

- After the continuous decrease since 2007, 2012 is the first year when production of clinker and emission in 2.A.1 sector has increased again (+4.7%) in Hungary;
- Emissions decreased in all the other subsectors in Industry;
- Emissions have also decreased in sector 2.F Consumption of F-gases, mainly due to the decreasing trend of import-export in 2.F.1 Refrigeration and air-conditioning subsector.

### Major changes compared to previous submission:

- Emission in 2.A.2 Lime production subsector are now calculated using EU ETS data for the years 2005-2012 and using average IEF of these years for the calculation of the years before 2005;
- CO<sub>2</sub> emissions are now reported from sector 2.A.4 Soda Ash consumption;
- Emissions from blast furnace gas used for energy purposes have been reallocated from 2.C.1.4 Coke consumption in Iron and Steel Industry sector into Energy sector;
- Disposal emissions in 2.F.1 Refrigeration and air conditioning sector are now calculated without using high recovery efficiency factor of the GPG;
- Time series of 2.F.4 Aerosols and MDI subsector include now import in products too;
- Emission calculations are based now on IEA/Eurostat data in 2.G Feedstock and non-energy use of fuels sector.

### 4.1 Overview of sector

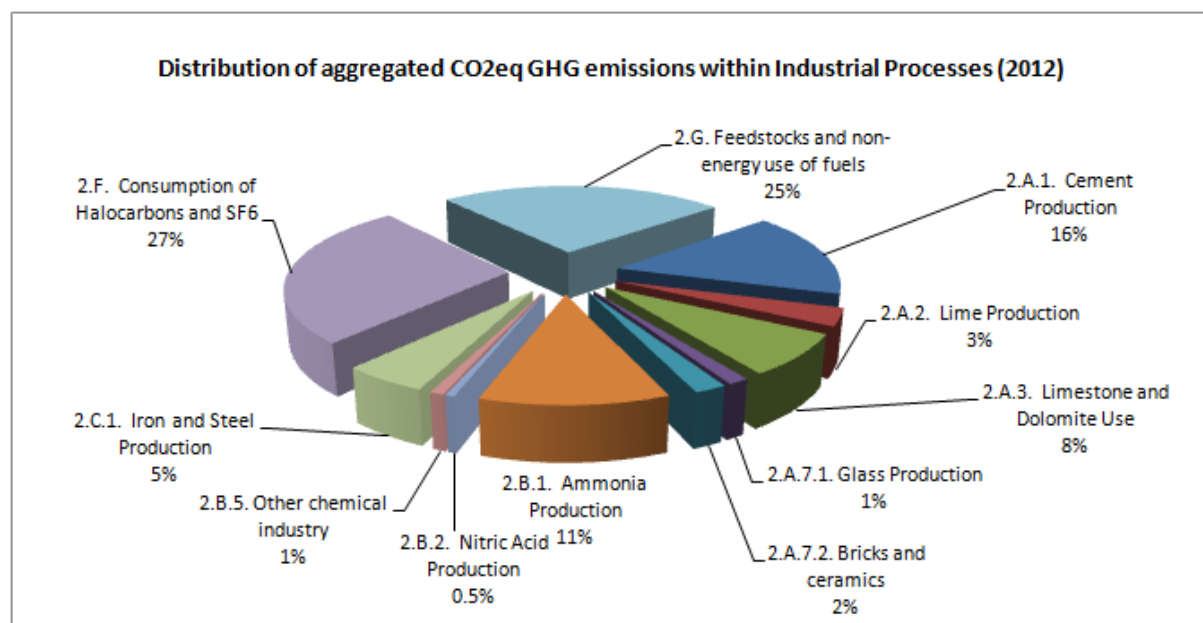
Industrial Processes sector includes emissions generated by non-firing processes related to industrial production. Emissions from the industrial processes are the third largest following the energy and agriculture sectors (see *Figure 2.7* in Chapter 2).

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>), aluminum (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, 2012 (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.

EU ETS data reported by the individual operators (summed together by industrial sector) is more accurate than the use of default factors, its use in inventory preparation needs special attention due to time series consistency problems. Last year the time series consistency of the sectors using EU ETS data after 2005 was analyzed and reviewed if needed. The results of the analysis are included in Annex 3 of the NIR. In the Industrial Processes sector EU ETS data is directly used in sector 2.A.1 Cement production, 2.A.2 (since 2014 submission), 2.A.7 Other mineral (Glass and Bricks and ceramics) and partly in 2.A.3 Limestone and dolomite use.

In the case of indirect greenhouse gases, consistency with CLRTAP/NEC reporting has been reached in 2014 submission. The calculation method of the indirect GHG and SO<sub>2</sub> emissions is described in detail in Informative Inventory Report of Hungary submitted for CLRTAP reporting, available at:

[http://www.ceip.at/ms/ceip\\_home1/ceip\\_home/status\\_reporting/2014\\_submissions/](http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/)

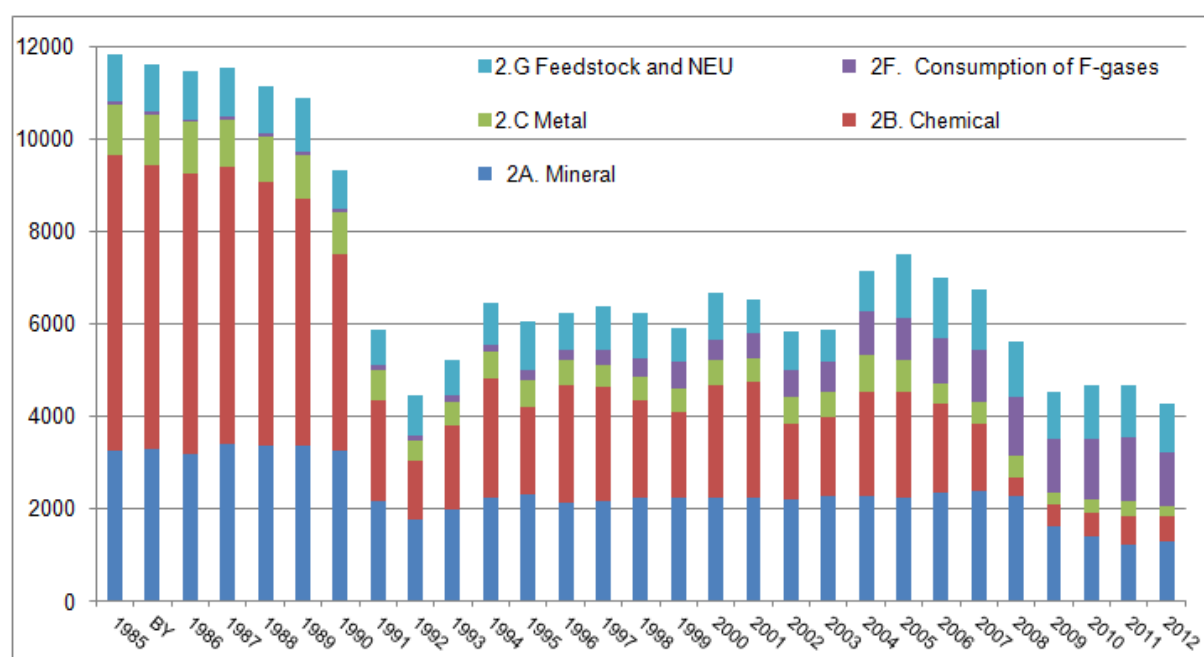
## 4.2 Emission Trends

Total emissions estimated from industrial processes were 4273.9 CO<sub>2</sub>-eq in 2012, or 6.9% of the total national emissions compared to 12.8% in the base year. Total sectoral emissions decreased by -63.2 % between the base year and 2012, and decreased by -8.7% between 2011 and 2012.

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. There was a slight growth in year 2010 and 2011, but GHG emissions from industrial processes sector were again 8.7% (406.3 Gg) lower in 2012 than in 2011.

Figure 4.2 shows the trend of GHG emissions from Industrial Processes by sub-categories for the years 1985 to 2012. The reallocation of emission from coke consumption in Iron and Steel industry between Energy sector to Industry sector performed in 2012 and 2014 submission has changed the ranking and proportion of the sub-sectors within Industrial Processes compared to the submissions of years before.

Chemical industry was the most important emitter in the beginning of the inventory period, especially  $N_2O$  emission from nitric acid production (for details see there). 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  $N_2O$  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  $SF_6$  has also stopped in 2008.



**Figure 4.2** GHGs emissions from Industry sector, 1985-2012 (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;
- Aluminum: two out of three plants were closed down in 1991 and the aluminum 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).

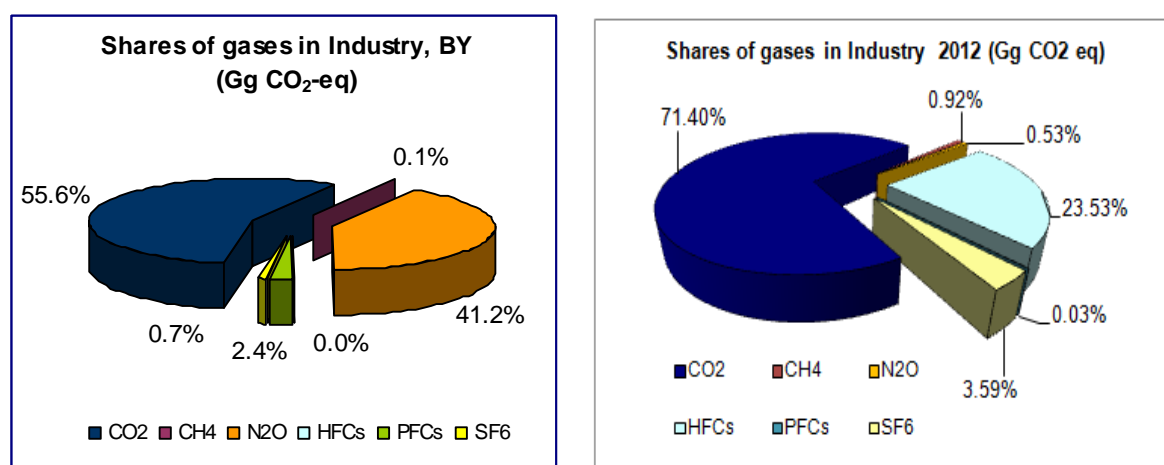
The privatization was slower in the industry than in other areas of the economy. Foreign investments were made rather in medium or smaller sized enterprises than in the big companies of the Hungarian industry.

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.

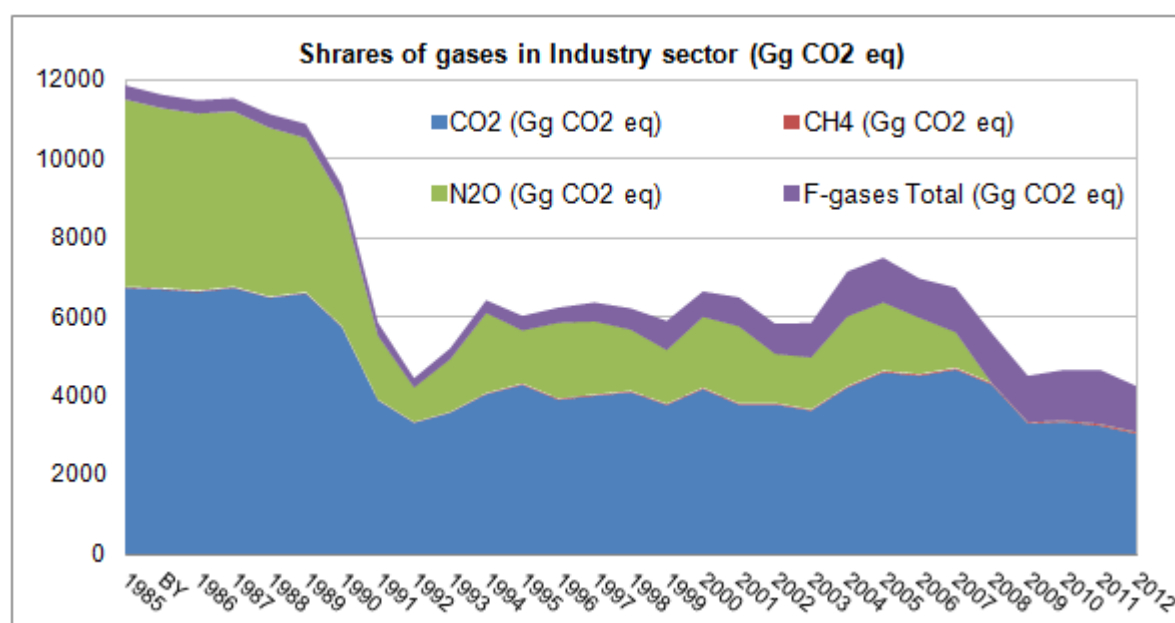
### 4.2.1 Emission Trends by Gases

The most important GHG in Industrial Processes sector is carbon dioxide, contributing 71.4% to total GHG emissions in this sector in 2012, followed by hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>) contributing 27.2% to GHG emissions CH<sub>4</sub> and N<sub>2</sub>O contributed 0.9% and 0.5%, respectively (Figure 4.3). Total sectoral emissions decreased by 63.2% between base year and 2012.



**Figure 4.3** Shares of gases in Industry sector, in base year and 2012 (Gg CO<sub>2</sub>-eq)

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



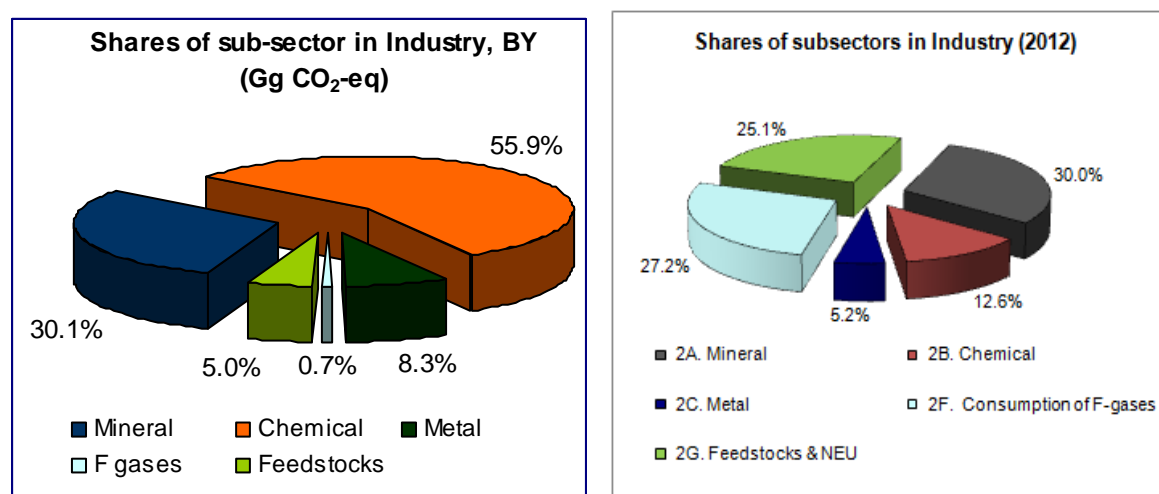
**Figure 4.4** The most significant greenhouse gases in Industry sector

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 2012 mineral sub-sector accounted for 30.0% followed by F-gases 27.2%, feedstock and non energy use of fuels 25.1%, chemical sub-sector 12.6% and iron and steel industry 5.2% (see *Figure 4.5* and *Table 4.1*).



**Figure 4.5** Shares of sub-sectors in Industry sector, in base year and 2012 (Gg CO<sub>2</sub>-eq)

**Table 4.1** Emissions of Industrial processes sector in 2012 (CO<sub>2</sub>-eq)

GHG emissions in 2012 (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>3051.4</b>	<b>39.1</b>	<b>22.8</b>	<b>1160.5</b>	<b>4273.9</b>
A. Mineral products	1281.1	0.00	0.00	0.00	1281.1
B. Chemical Industry	481.7	35.0	22.8	0.00	539.5
C. Metal Production	217.7	4.1	0.00	0.00	221.8
D. Other Production	0.00	0.00	0.00	0.00	0.0
E. Production of HFC/PFC/SF <sub>6</sub>	0.00	0.00	0.00	0.00	0.0
F. Consumption of HFC/PFC/SF <sub>6</sub>	0.00	0.00	0.00	1160.5	1160.5
G. Other	1071.0	0.00	0.00	0.00	1071.0

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

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

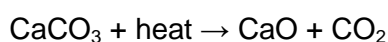
#### 4.3.1.1 Source category description

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 five 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 601/2012/EC EU ETS Monitoring and Reporting Regulation). 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.

Significant decrease of emissions has 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 since 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; 2011: 86.7; 2012: 93,9). Although the volume index in 2012 is still decreasing, emissions are 4,7% higher in 2012. This fact might be explained by the fact that although there was a decrease in cement production, clinker production increased and CO<sub>2</sub> emissions are rather connected to clinker production technology. However these strange trends need further investigation.

#### 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.

Emissions were estimated using a country specific method similar to the IPPC Tier 2 methodology. In 2012 five 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 2012 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 (1985-2012)

	1985	B Y	1986	1987	1988	1989	1990	1991	1992	
<b>Raw, kt</b>	5044.1	5151.8	4981.6	5429.6	5263.7	5338.2	5148.0	3247.3	2533.2	
<b>Clinker, kt</b>	3097.9	3173.2	3069.5	3352.1	3250.5	3320.7	3210.4	2067.3	1591.3	
<b>Cement, kt</b>	3670.8	3888.9	3845.2	4150.8	3871.4	3856.8	3932.8	2563.2	2245.6	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
<b>Raw, kt</b>	3009.6	3476.5	3493.0	3274.8	3463.0	3603.0	3617.2	3998.1	4008.5	4218.3
<b>Clinker, kt</b>	1906.7	2211.0	2214.2	2034.0	2184.8	2262.1	2270.6	2531.8	2522.0	2687.1
<b>Cement, kt</b>	2521.3	2795.3	2874.9	2745.0	2806.2	2995.1	2979.1	3348.2	3452.4	3504.2
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Raw, kt</b>	4209.1	3828.2	3578.8	3884.3	3938.7	3747.0	2889.3	2181.2	1 672.4	2047.2
<b>Clinker, kt</b>	2696.1	2494.8	2352.6	2533.1	2577.1	2468.4	1883.0	1433.2	1 109.4	1332.6
<b>Cement, kt</b>	3564.9	3266.7	3363.5	3722.9	3485.1	3569.8	2808.5	2133.9	1 692.2	1478.4

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 (1985-2012)

	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	2002
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	1,434.8
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	42.4
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	1,477.2
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO <sub>2</sub> from CaCO <sub>3</sub> , kt	1,404.8	1,291.0	1,198.9	1,295.9	1,328.1	1,260.6	972.7	735.4	563.6	678.4
CO <sub>2</sub> from MgCO <sub>3</sub> , kt	47.5	49.6								
Total CO <sub>2</sub> , kt	1,452.4	1,340.6	1,198.9	1,295.9	1,328.1	1,260.6	972.7	735.4	563.6	678.4

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 (1985-2012)

	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	2002
CO <sub>2</sub> /clinker	0.5513	0.5493	0.5505	0.5621	0.5529	0.5539	0.5546	0.5510	0.5581	0.5498
CO <sub>2</sub> /cement	0.4169	0.4345	0.4239	0.4165	0.4305	0.4184	0.4227	0.4166	0.4077	0.4216
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO <sub>2</sub> /clinker	0.5387	0.5374	0.5096	0.5116	0.5153	0.5107	0.5166	0.5131	0.5081	0.5091
CO <sub>2</sub> /cement	0.4074	0.4104	0.3565	0.3481	0.3811	0.3531	0.3463	0.3446	0.3331	0.4589

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 probably 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.

Since 2011 reporting of the companies shows the particular situation that cement and clinker production are not in strong correlation with each other anymore as it is possible to observe

<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.

in Table 4.2. So, for example not all the factories produce cement from (all their) clinker or the cement is produced from clinker produced in earlier years based on the declarations of the companies. Considering this fact, unfortunately the implied emission factors are not reflecting clearly anymore the GHG intensity/efficiency of the production. Therefore also comparisons and verifications are very difficult to perform.

#### 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 601/2012/EC Regulation on Monitoring and Reporting in EU ETS), we believe that the use of ETS data improves the accuracy of the data reported in the inventory. Results of the analysis of the consistency of the time-series is included in Annex 3 of the NIR.

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

General QA/QC procedures apply. In addition results of the analysis of EU ETS data and resulting IEF and information regarding the issue of the decrease of IEF of t CO<sub>2</sub>/ t clinker between 2003-4 and 2005 is included in NIR Annex 3.

#### 4.3.1.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.3.1.6 Source-specific planned improvements

Further investigation of the issue of outlier IEFs of year 2004-5 described in NIR Annex 3 is needed in addition to the application of 2006 IPCC Guidelines.

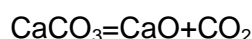
### 4.3.2 Lime Production (CRF Sector 2.A.2)

#### 4.3.2.1 Source category description

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

Key source: Trend in Tier 1 analysis

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 1.A.2..

During the 2012 EU Technical review a question was raised, whether the autoproduction of lime of sugar producers is included. The investigation resulted that sugar producing companies have never reported technological (originating from dissociation of limestone) emissions in EU ETS annual emission report (as they do not have this emission source in their GHG emission permit). However the practice is right because no technological CO<sub>2</sub> emissions arise from Hungarian sugar producers since all of them use Ca(OH)<sub>2</sub> + CO<sub>2</sub> precipitation technology to remove impurities. This technology is described in the sector specific IPPC BAT BREF document as well.

(Available at: [http://eippcb.jrc.es/reference/BREF/fdm\\_bref\\_0806.pdf](http://eippcb.jrc.es/reference/BREF/fdm_bref_0806.pdf))

#### 2.1.4.11.3 Description of techniques, methods and equipment

*Carbonation is the introduction of the milk of lime, calcium hydroxide, and carbon dioxide gas (CO<sub>2</sub>) into a liquid to form calcium carbonate and to precipitate and remove impurities. The effect of lime and CO<sub>2</sub> is the precipitation of insoluble calcium salts, the flocculation of colloidal components, the chemical degradation of other molecules such as invert sugar and amides, and the absorption of non-sugars on precipitated calcium carbonate. Lime and CO<sub>2</sub> are normally produced in lime kilns by the thermal dissociation of limestone. )*

In addition Hungarian BAT reference document prepared in 2005 by Hungarian Sugar Industry Research Institute for the Ministry of Environment (available at: [http://www.ippc.hu/pdf/cukor\\_utmutato.pdf](http://www.ippc.hu/pdf/cukor_utmutato.pdf) unfortunately only in Hungarian) states that CO<sub>2</sub> emission from lime kilns in sugar production facilities are attributable solely to fuel combustion of the lime kilns since „CO<sub>2</sub> originating from dissociation of limestone is rebound again into CaCO<sub>3</sub>.” (Section 4.1.2.2.2) Fuel consumption of lime kilns are reported in Energy sector. Precipitated CaCO<sub>3</sub> is used for liming of soils in general (reported in LULUCF sector).

#### 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.

In category 2.A.2 Lime production category time series have been recalculated by using EU ETS emission data of companies in years 2005-2012 and using the average of the IEFs of these years for the years before 2005. The IEF of years between 2005 and 2012 do not show a clear trend as it is presented in the following Figure, therefore the average seems to be applicable for extrapolation for the years before 2005 in order to reach consistent time series. The average of years 2005-2012 results in 0.7388 t CO<sub>2</sub>/t lime produced which is 5.9% lower than the stoichiometric IEF of 0.785 and it is well fitting in the IEF range 0.56-0.8 applied by other countries as presented in SAI 2013.

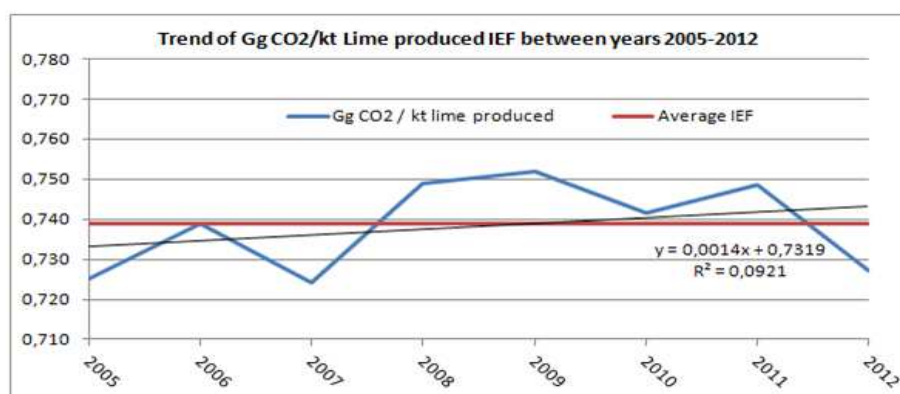
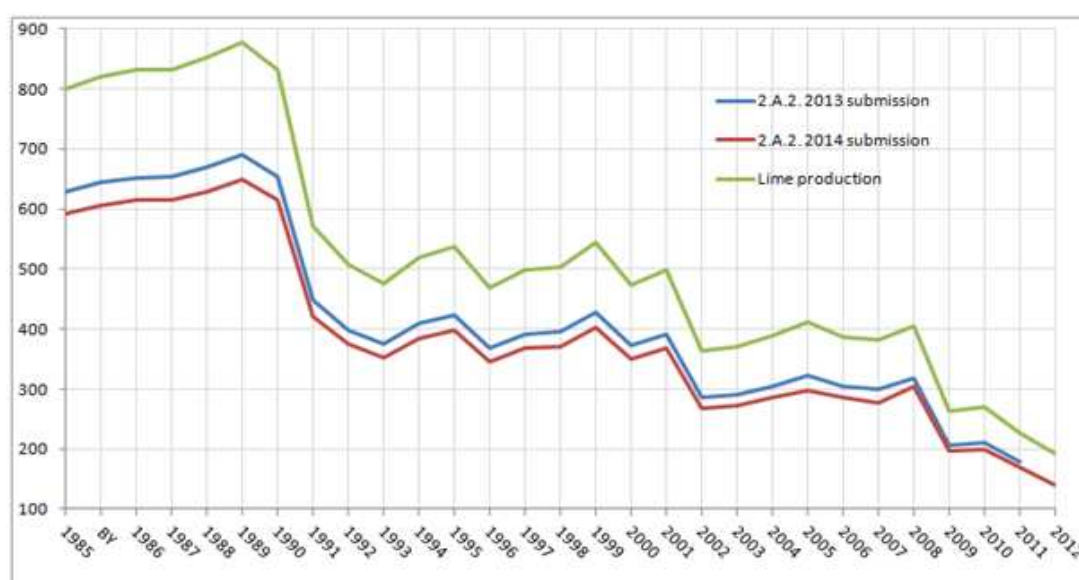


Figure 4.6 Trend of Gg CO<sub>2</sub>/kt Lime produced IEF between years 2005-2012

Exact carbonate contents of the raw material and the remaining carbonate content of the products determined by accredited laboratories are used for the calculations in EU ETS Annual Emission Reports (AERs). Using EU ETS data, the emissions from the minor proportion of dolomitic lime (containing  $\text{MgCO}_3$ ), impurities and the eventual presence of hydraulic lime (which has the same stoichiometric ratio as lime but has a lower  $\text{CaO}$  content (see page 3.22 of the GPG)) are also taken into account as it is required by GPG chapter 3.1.2.1.

**Table 4.5** Specific  $\text{MgCO}_3$  and remaining carbonate contents in EU ETS 2012 data

	2012.
MgCO <sub>3</sub> content of raw material in EU ETS AER-s	0.44%-2.24%
Conversion factors due to remaining carbonate content of the product in EU ETS AER-s	0.901-0.979



**Figure 4.7.** Time series in sector 2.A.2.Lime

#### 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. Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR. The recalculation in 2014 submission was performed in order to improve the consistency the time series as it is described above.

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

General QA/QC procedures apply. In addition the activity data is received both directly from the operators and from the HCSO which allows the verification of time-series..

#### 4.3.2.5 Source-specific recalculations

Comparison Table of old and new time series are included in NIR chapter 10.

#### 4.3.2.6 Source-specific planned improvements

Application of 2006 IPCC Guidelines.

### **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: Level in Tier1 analysis

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. In this sector limestone and dolomite use for flue gas scrubbing and for iron and steel industry are included.

Situation of other possible uses of limestone and dolomite in Hungary:

- Carbide production is not occurring in Hungary as far as our knowledge;
- various uses during iron and steel production are included in 2.A.3;
- emissions from carbonates during production of clay-based products are included in 2.A.7.2 Bricks and ceramics
- emissions from carbonates during production of glass are included in 2.A.7.1 Glass, which includes also glass wool production.

We have no information of other uses of limestone and dolomite in Hungary.

#### **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. Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply.

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

Last year there was no recalculation.

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

Application of 2006 IPCC Guidelines is planned.

#### 4.3.4 Soda Ash Use (CRF sector 2.A.4.)

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

Key source: no

##### 4.3.4.1 Methodological issues

Carbon dioxide is released when soda ash (Na<sub>2</sub>CO<sub>3</sub>) is heated.

During 2013 centralized review the ERT recommended to compare Total import-export data of soda ash in Hungary and soda ash use in glass production in order to ensure that all soda ash uses are reported. (Please note that soda ash is not produced in Hungary.) Although the difference changes year by year, the sum of 2005-2012 of Total import-export is higher than the sum of soda ash used in glass industry in 2005-2012. Therefore additional reporting of CO<sub>2</sub> emission arising from soda ash not used in glass industry is needed in 2.A.4.

Consequently, Hungary has resubmitted its emission estimates.

##### Activity Data

##### *Total import/export of soda ash*

Time series of activity data is presented in Table 4.9. As it was recommended by the ERT, total domestic soda ash consumption has been estimated “from domestic production plus net imports data available from statistics of UN comtrade (<http://comtrade.un.org>) (imports minus exports, for disodium carbonate)”.

Both HS classification code 283620 and SITC classification code 52323 for disodium carbonate results the same time series. Hungarian Central Statistical Office publishes import-export data from year 2003 on its website. Differences between UNComtrade data and HCSO data are below 0,007% (6(t) Na<sub>2</sub>CO<sub>3</sub>)).

No data is available for years before 1991 on import/export of soda ash neither in UNComtrade and EUROStat databases, nor in the database of the Hungarian Central Statistical Office. Therefore extrapolation was needed applying volume indices of TOTAL trade presented in Table 4.6 as sector specific volume indices are available only from 1999 within the databases mentioned above.

**Table 4.6** *Volume indices of Total trade*

		1985	1986	1987	1988	1989	1990	1991	1992
<b>Volume indices of trade (compared to previous year)</b>	import	0.98	0.98	1.00	0.97	1.08	0.83	1.21	0.83
	export	1.02	0.97	0.94	1.00	1.04	1.05	0.99	1.15

Source: [http://www.ksh.hu/docs/hun/xstadat/xstadat\\_hosszu/h\\_gkt001.html](http://www.ksh.hu/docs/hun/xstadat/xstadat_hosszu/h_gkt001.html)

Additional gap filling was needed for years 1994 and 2006 due to lack of export data. In these cases average of export data of year before and after was used.

##### *Determination of the amount of soda ash not used in glass industry*

Comparison of Total domestic soda ash consumption and soda ash used in glass industry is presented in Table 4.7. The data on Na<sub>2</sub>CO<sub>3</sub> used in EU ETS glass production have been extracted from the EU ETS Annual Emission Reports of the glass producing companies.

Please note that several values have been changed since the review response sent on the 27th September 2013 because of the inclusion of 2012 data and an additional review of the of the EU ETS Annual Emission Reports of the glass producing companies.

**Table 4.7** Comparison of Total domestic soda ash consumption and soda ash used in glass industry

	2005	2006	2007	2008	2009	2010	2011	2012	Average of 2005-2012
Total import-export (t) $\text{Na}_2\text{CO}_3$	94 739.6	83 936.0	60 067.5	58 859.1	47 064.2	56 856.5	61 102.0	64 327.3	65 869.1
(t) $\text{Na}_2\text{CO}_3$ in EU ETS Glass	85 063.3	72 141.6	72 464.1	63 665.3	55 903.1	52 586.2	53 054.0	57 512.3	64 048.7
<b>(t) <math>\text{Na}_2\text{CO}_3</math> difference</b>	<b>9 676.3</b>	<b>11 794.4</b>	<b>-12 396</b>	<b>-4 806.3</b>	<b>-8 838.9</b>	<b>4 270.4</b>	<b>8 048.0</b>	<b>6 815.1</b>	<b>1 820.3</b>
<b>Gg <math>\text{CO}_2</math> from the difference</b>	<b>4.02</b>	<b>4.89</b>	<b>-5.14</b>	<b>-1.99</b>	<b>-3.67</b>	<b>1.77</b>	<b>3.34</b>	<b>2.83</b>	<b>0.755</b>
<b>t <math>\text{Na}_2\text{CO}_3</math> difference /Total</b>	<b>10.2%</b>	<b>14.1%</b>	<b>-20.6%</b>	<b>-8.2%</b>	<b>-18.8%</b>	<b>7.5%</b>	<b>13.2%</b>	<b>10.6%</b>	<b>2.76%</b>

t)  $\text{Na}_2\text{CO}_3$  difference = Soda ash NOT used in glass production = AD of 2.A.4 = {Total (import- export) (t)  $\text{Na}_2\text{CO}_3$ } - {(t)  $\text{Na}_2\text{CO}_3$  in EU ETS glass}

In several years the soda ash used in glass production is higher than the Total (import-export), while in other years it is lower. We assume this changing trend might be due the volatility of the market and the stockpile of the glass producing companies.

In order to level off negative values, average values of the years 2005-2012 are taken into consideration. The average of soda ash NOT used for glass production /year is 1820 t/year, which results 0.755 Gg  $\text{CO}_2$ /year. The average of soda ash NOT used in glass production (=1820.3 t) compared to the average of Total import – export (=65869.1 t) results 2.76% .

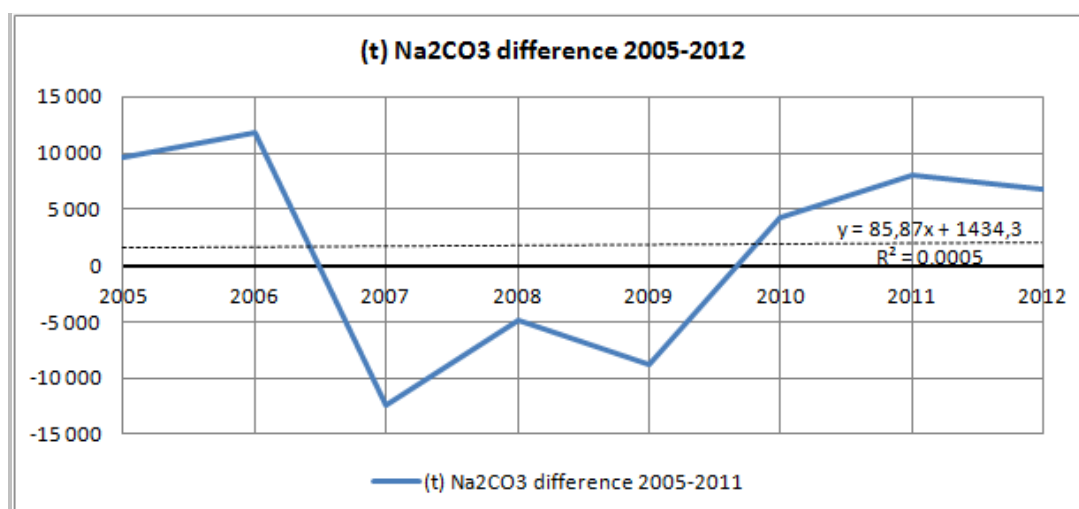
In other words, the difference between the SUM of Total import-export of soda ash and the SUM of soda ash used in glass production is 2.76% as it is presented in Table 4.8.

**Table 4.8** SUM of Total domestic soda ash consumption and soda ash used in glass industry

	SZUM of 2005-2012
Total import- export (t) $\text{Na}_2\text{CO}_3$	526 952.4
(t) $\text{Na}_2\text{CO}_3$ in EU ETS glass	512 390.0
<b>(t) <math>\text{Na}_2\text{CO}_3</math> difference</b>	<b>14 562.5</b>
<b>t <math>\text{Na}_2\text{CO}_3</math> difference /Total</b>	<b>2.76%</b>

So, for our calculations, 2.76% of the Total import-export data of the given year is considered to be the amount of soda ash NOT used in glass production.

The ratio of 2.76% seem to be applicable for extrapolation for years before 2005 as the slope of the trend is quite small:  $R^2 < 0.1$  as it is presented on Figure 4.8.



**Figure 4.8** Trend of soda ash not used in glass production

So, the following equation is applied for the entire time series and the results are presented in Table 4.9 below:

Soda ash NOT used in GLASS industry in year (n) = AD of 2.A.4.=

(Total import-export of soda ash in year (n) ) \*2.76%

Emission factor and CO<sub>2</sub> emission of sector 2.A.4.

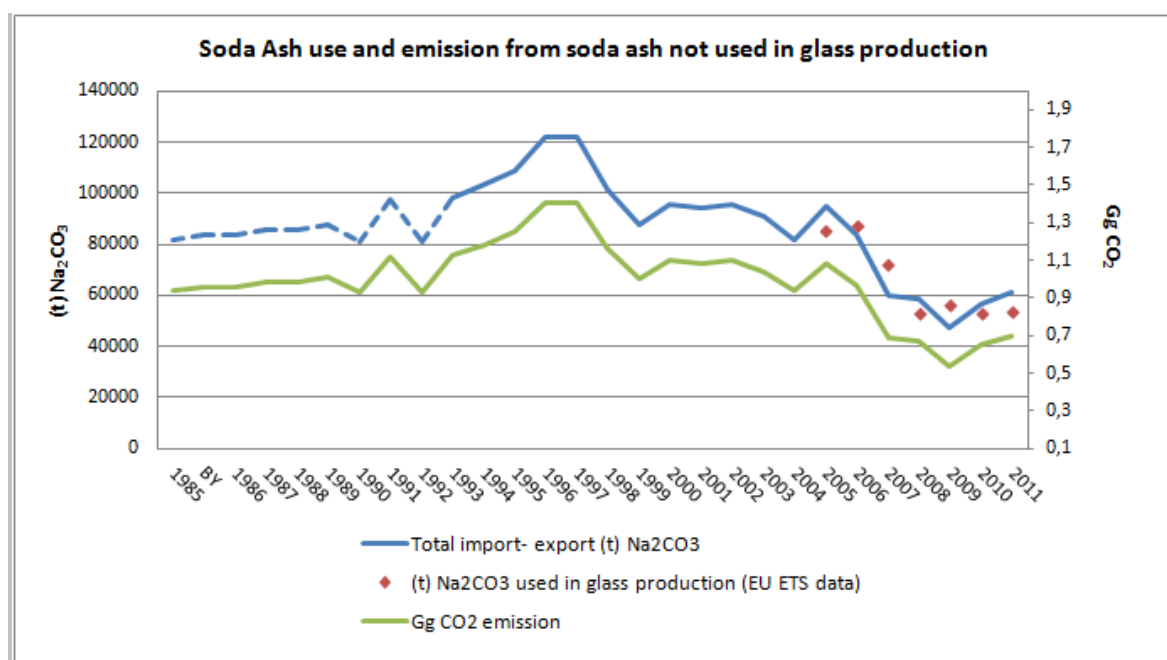
Emission factor of 0,415 t CO<sub>2</sub>/ t Na<sub>2</sub>CO<sub>3</sub> of IPCC1996 chapter 2.6.2 is used, which is a stoichiometric factor assuming that all soda ash is dissociated.

(44.01 g/mole CO<sub>2</sub> /105.99 g/moleNa<sub>2</sub>CO<sub>3</sub> = 415 kg CO<sub>2</sub>/tonne Na<sub>2</sub>CO<sub>3</sub>)

The following Table and Figure summarizes the time series of activity data and CO<sub>2</sub> emissions in sector 2.A.4 Soda Ash use.

**Table 4.9** Activity data and CO<sub>2</sub> emission in 2.A.4.of several years

	source of data	Total import- export (t) Na <sub>2</sub> CO <sub>3</sub>	Soda ash NOT used in GLASS industry (t)	Gg CO <sub>2</sub> emission
<b>1985</b>	extra-polated using annual volume index of trade	81713.1	2 258.2	<b>0.94</b>
<b>BY</b>		83765.5	2 314.9	<b>0.96</b>
<b>1992</b>		80743.3	2 231.4	<b>0.93</b>
<b>1993</b>	UN Comtrade	97969.9	2 707.4	<b>1.12</b>
<b>1994</b>	intra-polated	103232.4	2 852.9	<b>1.18</b>
<b>1995</b>	UN Comtrade	108992.4	3 012.0	<b>1.25</b>
<b>2005</b>		94739.6	2 618.2	<b>1.09</b>
<b>2006</b>	intra-polated	83936.0	2 319.6	<b>0.96</b>
<b>2007</b>	UN Comtrade	60067.5	1 660.0	<b>0.69</b>
<b>2010</b>		56856.5	1 571.2	<b>0.65</b>
<b>2011</b>		61102.0	1 688.6	<b>0.70</b>
<b>2012</b>		64327.3	1 777.7	<b>0.74</b>



**Figure 4.9** Trend of Total domestic consumption of soda ash and CO<sub>2</sub> emissions in sector 2.A.4.

#### 4.3.4.2 Source-specific QA/QC information and verification, uncertainties and planned improvements

General QA/QC procedures apply. In addition as it is mentioned above, activity data was verified with the Hungarian Central Statistical Office data. HCSO publishes import-export data only from year 2003 on its website. Differences between UNComtrade data and HCSO data are below 0,007% (6(t) Na<sub>2</sub>CO<sub>3</sub>)).

The same uncertainty values have been applied as in the case of 2.A.7 Other Mineral Industry. Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR.

Application of 2006 IPCC Guidelines is planned.

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

##### 4.3.5.1 Source category description

Emitted gas: NMVOC, CO

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

##### 4.3.5.2 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 emissions are reported. Activity data is taken from HCSO and European Asphalt Pavement Association, respectively. In this year default emission factors have been changed from the Revised IPCC1996 Guidebook to EMEP/EEA 2009 Guidebook emission factors.

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

General QA/QC procedures apply.

#### 4.3.5.4 Source-specific recalculations

None.

#### 4.3.5.5 Source-specific planned improvements

Review of EFs is planned based on the latest available EMEP/EEA Guidebook for Asphalt Roofing as well.

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

#### 4.3.6.1 Source category description

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

Key source: 2.A.7 in Trend in Tier1 analysis

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.

#### 4.3.6.2 Methodological issues

Considering the fact that all the glass factories are covered by EU Emission Trading System, the quantity of CO<sub>2</sub> reported by them was accepted as emissions between 2005 and 2012. The data of total produced quantity were provided by the HCSO. The CO<sub>2</sub> emission is only 50.82 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:

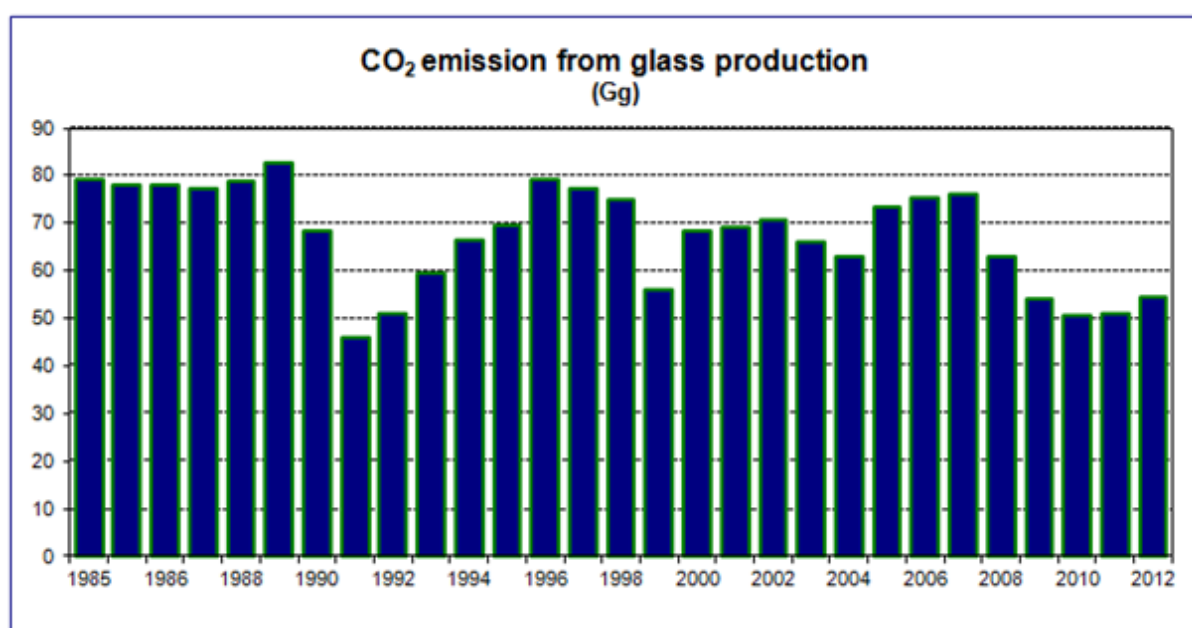


Figure 4.10 CO<sub>2</sub> emission from Glass Production (1985-2012)

#### 4.3.6.3 Source-specific QA/QC information and verification and time-series consistency and uncertainty

General QA/QC procedures apply. 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. Results of the analysis of the consistency of the time-series are included in Annex 3 of the NIR.

Please find the presently available uncertainty values in Table A7-1 in Annex 7 of the NIR.

#### 4.3.6.4 Source-specific recalculations

Last year there was no recalculation.

#### 4.3.6.5 Source-specific planned improvements

Further analysis of the consistency of activity data is needed. Application of 2006 IPCC Guidelines is planned.

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

#### 4.3.7.1 Source category description

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

Key source: 2.A.7 in Trend in Tier1 analysis

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.

#### 4.3.7.2 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 2012 was 83.1 Gg which is 0.14% of the total CO<sub>2</sub> emission. The following table contains the data of production and emission:

**Table 4.10** Bricks and ceramics production and CO<sub>2</sub> emission in Industry sector (1985-2012)

	1985	B.Y.	1986	1987	1988	1989	1990	1991	1992	
<b>Bricks and ceramics, kt</b>	6623.2	6339.6	5998.6	6397.0	6522.9	6104.1	6275.8	4509.4	3500.9	
<b>CO<sub>2</sub> Gg</b>	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	2002
<b>Bricks and ceramics, kt</b>	3978.9	4207.6	4784.3	4217.0	4222.7	4437.6	4162.3	3021.9	2728.3	2300.4
<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	204.2
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Bricks and ceramics, kt</b>	3018.6	3277.1	3763.0	3817.0	4841.0	4026.6	1482.6	1450.8	1 295.7	1143.2
<b>CO<sub>2</sub> Gg</b>	267.9	290.9	334.0	360.5	357.6	312.0	110.2	105.5	92.7	83.1

#### 4.3.7.3 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 601/2012/EC Regulation on the monitoring and reporting of greenhouse gas emissions in EU ETS). Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR.

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. Results of the analysis of the consistency of the time-series are included in Annex 3 of the NIR.

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

General QA/QC procedures apply. Results of the analysis of the consistency of the time-series are included in Annex 3 of the NIR.

#### 4.3.7.5 Source-specific recalculations

None.

#### 4.3.7.6 Source-specific planned improvements

Application of 2006 IPCC Guidelines is planned.

### 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 has increased since 2010, which is reflected in the volume index of industrial gross output (corresponding period of the previous year= 100 (per cent): 2009: 83.9; 2010: 113.7; 2011: 107.7; 2012: 106.5).

Although production of chemical industry is increasing, emissions in 2B sector are 10% lower than in 2012. This fact might be explained by the increasing environmental performance of the chemical plants. It is also worth to take into consideration that a significant part of the CO<sub>2</sub> emissions from petrochemical industry are allocated in sector 2.G at the moment.

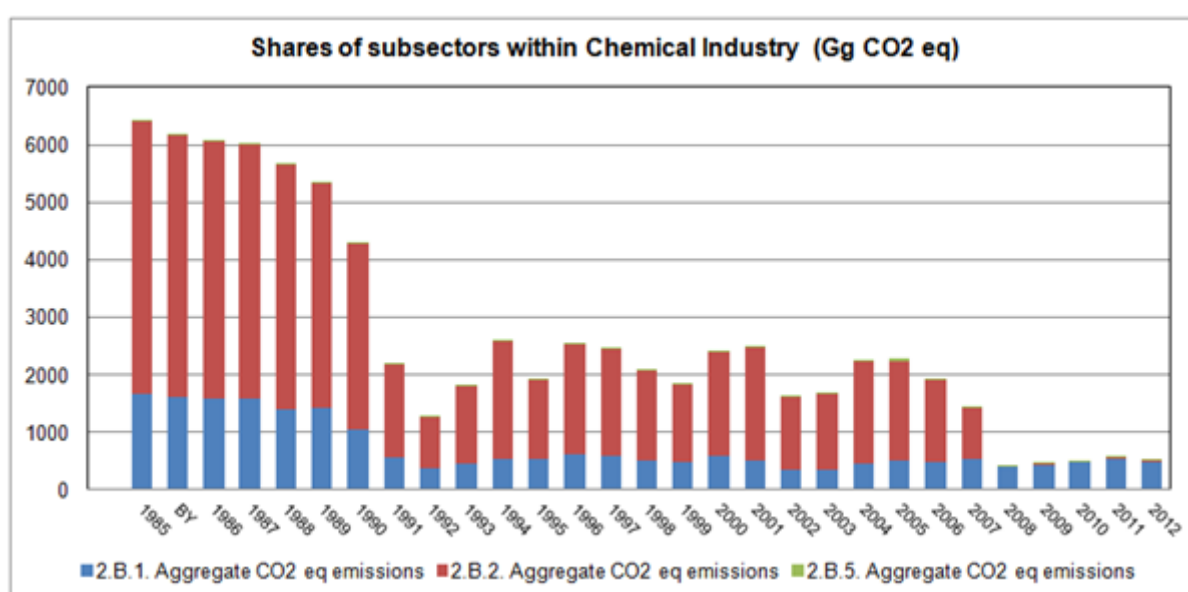


Figure 4.11 Total emission from Chemical sub-sector (1985-2012)

### **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 normal catalytic steam reforming technology using natural gas as a feedstock and the other changed to a hydrogen/nitrogen-based technology in 2002. The latter acquires hydrogen produced by other company. Emissions from hydrogen production are included in sector 2G (and/or in sector 1A as it is described by sector 2.G).

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.

During the 2012 EU Technical review a question was raised, whether urea production is accounted in Hungary. The investigation resulted that urea is produced in one ammonia producer plant. It is assumed that emissions are accounted since the estimation is based on the reporting on the use of natural gas as a feedstock for the whole company. We have no information on dry ice production in Hungary. In addition IPCC1996 chapter 2.8.3 states:

"The CO<sub>2</sub> from ammonia production may be used for producing urea or dry ice. This carbon will only be stored for a short time. Therefore, no account should consequently be taken for intermediate binding of CO<sub>2</sub> in downstream manufacturing processes and products." ( ...)

"When a deduction is made for CO<sub>2</sub> used in urea production it is good practice to ensure that emissions from urea use are included elsewhere in the inventory." (3.2.2.1) ( ...)"Emissions of CO<sub>2</sub> from urea use should be accounted for in the corresponding sectors. In particular, emissions from urea use as fertilizer should be included in the Agriculture Forestry and Other Land Use (AFOLU) Sector (see Volume 4)" (Box3.2)".

#### **4.4.1.2 Methodological issues**

Initially, production data published by HCSO 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 4.11** 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 (1985-2012)

	1985	BY	1986	1987	1988	1989	1990	1991	1992	
Natural gas, kt	685.86	661.26	651.80	646.13	574.42	585.67	432.05	230.34	148.92	
CO <sub>2</sub> , Gg	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	
IEF CO <sub>2</sub> (t/tNH <sub>3</sub> )	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	2002
Natural gas, kt	186.69	222.47	223.70	247.69	237.39	212.17	191.94	241.86	212.31	144.3
CO <sub>2</sub> , Gg	456.30	543.74	546.74	605.39	580.21	518.56	469.13	591.14	518.92	352.7
IEF CO <sub>2</sub> (t/tNH <sub>3</sub> )	1.57	1.49	1.45	1.43	1.41	1.48	1.48	1.38	1.32	1.32
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Natural gas, kt	143.54	184.74	208.03	195.59	213.77	160.91	177.01	192.52	222.55	197.1
CO <sub>2</sub> , Gg	350.84	451.52	508.44	478.05	522.47	393.28	432.63	470.55	543.93	481.7
IEF CO <sub>2</sub> (t/tNH <sub>3</sub> )	1.34	1.29	1.28	1.29	1.28	1.34	1.28	1.29	1.26	1.26

The Table 4.11 above indicates that tCO<sub>2</sub>/tNH<sub>3</sub> IEF value is between 1.28 and 1.76.

The continuous decrease of implied emission factor might be attributed to the fact, that obsolete technologies are abandoned. The existing factories have invested in several modernization and energy rationalization projects in recent years, which improved environmental performance and resulted decrease of emissions/unit of ammonia produced. Several environmental investments are listed on the public website of the company responsible for most of the production too, which explains the decrease of implied emission factor. The energy rationalization projects are for example:

2002 Ammonia Plant (expansion turbine) To utilize the pressure energy of the natural gas coming in pipeline to generate electricity

2003 Ammonia Plant (natural gas saturation) To reduce natural gas consumption

2005 Ammonia Plant Modernization of gas compressor

([http://www.nitrogen.hu/nat/index.php?option=com\\_content&view=article&id=122%3Akoernyezetvedelmi-beruhazasok&catid=9%3Akoernyezetvedelem&Itemid=19&lang=en](http://www.nitrogen.hu/nat/index.php?option=com_content&view=article&id=122%3Akoernyezetvedelmi-beruhazasok&catid=9%3Akoernyezetvedelem&Itemid=19&lang=en) )

From 2013, the extension of scope of EU ETS to ammonia production too is an incentive for further energy rationalization.

Please note that in HU CRF submissions the activity data is natural gas (kt) used for ammonia production and not the amount of ammonia produced (kt) as in the case of IPCC1996 Table 2-5 default values. CO<sub>2</sub> emission is calculated based on natural gas consumption of operating plants using 56.1 (t CO<sub>2</sub>/ TJ) and 34 (MJ/m<sup>3</sup>) default values. HU IEF calculated based on ammonia production is: 1.263 t CO<sub>2</sub> / t ammonia in 2012.

#### 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 %). Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply. The quality and reliability of the emission data were greatly improved by using production data obtained directly from the factories. In 2013 data

provided by the factory Nitrogénművek (responsible for the 90-95% of Hungarian production) was fully reviewed and the time series have been affirmed. The decreasing IEF of CO<sub>2</sub> is also verified and the result is described in the Methodological issues subchapter above.

#### 4.4.1.5 Source-specific recalculations

Last year there was no recalculation.

#### 4.4.1.6 Source-specific planned improvements

Follow up of the investigation of the issue of hydrogen production, and reallocation of process emissions if relevant. Verification with EU ETS annual emission reports will be possible for technological emissions from ammonia production as well, since this sector is included within the scope of EU ETS from 2013. In addition the application of 2006 IPCC Guidelines is planned.

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

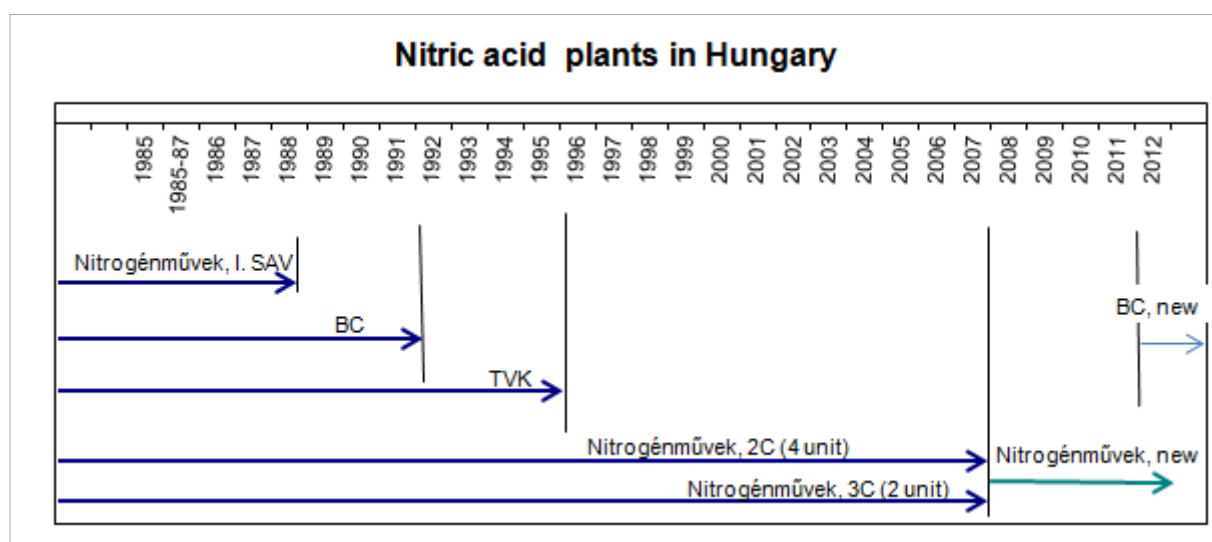
#### 4.4.2.1 Source category description

Emitted gas: N<sub>2</sub>O, (CO<sub>2</sub>)

Key source: N<sub>2</sub>O in Trend in Tier1 analysis

Nitric acid (HNO<sub>3</sub>) is produced by oxidizing ammonia. The process end gas contains N<sub>2</sub>O and NO<sub>x</sub>. 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 units. 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 4.12 shows the operating nitric acid plants between 1985 and 2012.*



**Figure 4.12** Nitric acid plants in Hungary, 1985-2012

Implementation of a new and more advanced production technology was started in 2005, in the framework of a joint implementation project (one of the flexible mechanisms 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 4.12*).

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))

At the end of year 2011 one of the former Nitric Acid plants has been restarted after renovation. Therefore the activity data and emission of year 2011 was revised in sector 2.B.2. Nitric Acid Production based on direct reporting of companies. The difference is no more than 0.01 Gg N<sub>2</sub>O in year 2011. Comparison Table of old and new time series are included in NIR chapter 10.

#### 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 and Nature).

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 using 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 of the years before 2007, 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, 0.0715 kg/t in 2010, 0.087kg/t in 2011 and 0.113 in 2012. The new factory of Nitrogénművek 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 ENVIINOx® SYSTEM	ppm vol.	max. 25	5.7	5.6	5.7	5.7	
NH <sub>3</sub> CONCENTRATION IN TAIL GAS DOWNSTREAM ENVIINOx® 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 ENVIINOx® 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 ENVIINOx® SYSTEM	mol H.C. / mol N <sub>2</sub> O	max. 0.2	0.077	0.078	0.077	0.077	

**Figure 4.13** Presentation of performance of EnviNOx technology

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 4.12** Nitric Acid production (kt) and N<sub>2</sub>O emission in Chemical sub-sector (1985-2012)

	1985	BY	1986	1987	1988	1989	1990	1991	1992	
<b>Nitric Acid, kt</b>	1,051.4	1,013.0	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	2002
<b>Nitric Acid, kt</b>	310.34	460.11	310.28	453.83	433.53	354.44	309.50	415.99	454.27	294.80
<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	4.044
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Nitric Acid, kt</b>	306.21	415.01	484.41	460.83	474.91	385.96	440.01	480.53	588.4	651.23
<b>N<sub>2</sub>O, Gg</b>	4.272	5.701	5.593	4.612	2.922	0.016	0.048	0.034	0.052	0.074

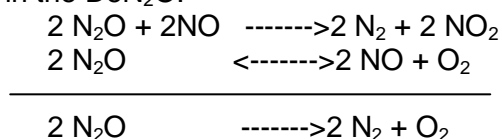
#### EnviNOx technology

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

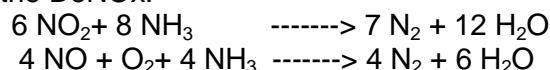
into  $N_2$  and  $O_2$ . Since  $NO_x$  content of the tail gas promotes the decomposition of  $N_2O$ , the required De $NO_x$  stage is arranged downstream of the De $N_2O$  stage.

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

Reactions in the De $N_2O$ :



Reactions in the De $NO_x$ :



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.

Please find the presently available uncertainty values in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply. 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).

The significantly decreasing IEF after 2007 is verified and the results are also described in the Methodological issues subchapter above.

#### 4.4.2.5 Source-specific recalculations

Recalculation of 2011 emission data is made due to the restart of another nitric acid producer plant. Please find the comparison table in chapter 10.

#### 4.4.2.6 Source-specific planned improvements

Verification with EU ETS annual emission reports will be possible for technological emissions from nitric acid production as well, since this sector is included within the scope of EU ETS from 2013. Application of 2006 IPCC Guidelines is planned.

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

#### 4.4.3.1 Source category description

Emitted gas:  $CH_4$

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 products, in 2010 ERT recommended the use of default factor, which is 11 kg CH<sub>4</sub>/t carbon black.

CO<sub>2</sub> emissions from carbon black production are included in 2.G sector as the feedstock used for carbon black production are reported as NEU in the IEA Energy Statistics.

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

General QA/QC procedures apply. Verification is performed in 2.G sector regarding petrochemical industry and carbon black production. For details please see chapter 4.9 on 2.G sector.

#### **4.4.3.4 Source-specific recalculations**

Last year there was no recalculation.

#### **4.4.3.5 Source-specific planned improvements**

Application of 2006 IPCC Guidelines and EMEP/EEA 2013 Guidebook in the case of indirect GHG emissions is planned.

### **4.4.4 Other chemicals (CRF sector 2.B.5.2-7.)**

#### **4.4.4.1 Source category description**

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

Key source: NO

#### **4.4.4.2 Methodological issues**

The following IPCC1996 default CH<sub>4</sub> emission factors are used:

- 2.B.5.2. Ethylene: 1 kg CH<sub>4</sub>/t ethylene
- 2.B.5.3. Dichloroethylene: 0.4 kg CH<sub>4</sub>/t dichloroethylene
- 2.B.5.5 Methanol: 2 kg CH<sub>4</sub>/t methanol

In subsectors 2.B.5.2-5.(Ethylene, Dichloroethylene, Methanol) production data obtained from KSH and default emission factors recommended by IPCC are used to calculate methane emissions. The sum of aggregated emissions from 2.B.2-5 is 0.694 Gg CH<sub>4</sub> (14.5 Gg CO<sub>2</sub> eq), showing a 0.5% increase compared to the previous year.

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. Therefore, CO<sub>2</sub> notation key was changed to IE after the recommendation of ARR of last year, since CO<sub>2</sub> emissions are reported in sector 2.G.

Ethylene may be produced from several kinds of feedstock. In Hungary it is produced mainly from naphtha, 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.

In subsectors 2.B.5.6.Sulfuric acid and 2.B.5.7.Other chemical industry solely indirect GHG emissions and SO<sub>2</sub> are reported using activity data obtained from the statistical office and IPCC default emission factors.

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

General QA/QC procedures apply. Several cross checks of the activity data time-series have been performed and consistency with CLRTAP reporting has been reached in the case of indirect GHGs.

#### **4.4.4.4 Source-specific recalculations**

There was no recalculation.

#### **4.4.4.5 Source-specific planned improvements**

Application of IPCC 2006 Guidebook and EMEP/EEA 2013 Guidebook in the case of indirect GHG emissions.

### **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: No

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). The gases arising in the blast furnace during the production of the pig iron are recovered as blast furnace gas (BFG) and used for energy purposes.

During steel production, the carbon content of iron is reduced from 4-5% to cc. 1%. ("below 2%" in IPCC1996 and GPG and 1% in IPCC2006). 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 cannot 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. Therefore in 2012

and 2013 submission all the emissions from coke consumption in blast furnace (including emissions from blast furnace gas) were reported in subsector 2.C.1.4, however it was a planned improvement to report the recovered blast furnace gas in Energy sector.

This planned improvement has been executed in present 2014 submission, so emissions from blast furnace gas have been separated and reported in 1.A.1.a and 1.A.2.a sectors as blast furnace gas is used in the energy sector in the reality. So, in fact this recalculation is only a reallocation between 2.C.1.4 and 1.A.1.a and 1.A.2.a subsectors.

In 2.C.1.4 subsector, emissions from blast furnace gas are reported as recovery, and are subtracted from CO<sub>2</sub> emissions.

In the following table the present allocation of emissions connected to Iron and steel production is summarized.

**Table 4.13** Allocation of emissions connected to Iron and steel production

IPCC sector code	Activity	Emission source	2012 and 2013 submission – Emission reported in	2014 submission - Emission reported in
1.A.1.a	Combustion of blast furnace gas recovered from Pig Iron production	combustion	2.C.1.4	1.A.1.a
1.A.1.c	Production of coke	combustion	1.A.1.c	1.A.1.c (including coke
1.A.2.a	Combustion needed for iron and steel production	combustion	1.A.2.a (including coke oven gas)	
1.A.2.a	Combustion of blast furnace gas recovered from Pig Iron production	combustion	2.C.1.4.	1.A.2.a
2.C.1.3	Sinter	Coke consumption during sintering	Included in 2.C.1.1	(correction of IE comment:) 1.A.2.a
		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 (including recovered blast furnace gas)
		Consumption of coke	Included in 2.C.1.4	Included in 2.C.1.4
		Consumption of Natural gas for non-energy purposes	2.C.1.2	2.C.1.2
		Limestone and dolomite use	IE to 2.A.3	IE to 2.A.3

IPCC sector code	Activity	Emission source	2012 and 2013 submission – Emission reported in	2014 submission - Emission reported in
2.C.1.4.	Consumption of coke	Consumption of coke in the blast furnace (after deduction of the amount of recovered blast furnace gas and the amount emitted during steel production process)	2.C.1.4.	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.

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

#### *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 as well as the amount of blast furnace gas (BFG) recovered and used.

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

Carbon dioxide is released from carbon content of pig iron and graphite electrode of the electric arc furnace (EAF) during steel production are reported in 2.C.1.1 Steel subsector.

During basic oxygen steel production the carbon content of the pig iron is converted from 4% to 1%. This means that 3% of carbon content present in pig iron is emitted as CO<sub>2</sub> and 1% of carbon content is stored in the steel.

Carbon content of the pig iron might originate from the coke consumed in the blast furnace, iron ore and additives. C content of pig iron from iron ores and additives is assumed to be the same amount as the carbon stored in the steel (1%), therefore it is not needed for the calculation.

So, the CO<sub>2</sub> emitted during steel production originates from C content of pig iron from coke. In order to avoid double counting these emissions should be subtracted from subsector 2.C.1.4 (Coke consumption).

The default carbon content of pig iron is: 4% (both IPCC1996, GPG and IPCC2006). In the

case of carbon content of steel IPCC1996 and GPG states that is “ below 2%” and IPCC2006 specifies it as 1%.Until 2014 submission 0.5% carbon content of the steel has been used, but it has now been updated to 1% based on IPCC2006 as it is in accordance with plant specific (EU ETS annual emission report) data.

Emissions in 2.C.1.1 sector are calculated using the following formula:

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

In the case of EAF steel production the 5 kg CO<sub>2</sub>/t steel emission factor provided in GPG is used.

In the case of EAF steel production the input material is usually scrap iron and other unknown material. This feedstock does 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. Emissions from the „flux” (limestone and dolomite additives) in the blast furnace are reported in 2.A.3 Limestone and dolomite use subcategory.

Emissions from natural gas used in the Blast furnace are reported in subsector 2.C.1.2. Pig Iron. In this year 2011 year data has been revised in IEA Energy Statistics, therefore the emissions of year 2011 are recalculated, please find comparison table in chapter 10.

Please note that the steep decrease of IEF between 2008-2009 and 2011- 2012 is because the activity data in IEA Energy statistics. In addition the AD in the CRF is Pig Iron production (kt), because it is not possible to choose TJ as the unit of measure in CRF software. Therefore the change of the IEF is even bigger.

#### 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. One part of the emissions originating from coke is emitted during pig iron production, one part is emitted during steel production and the most part is recovered as blast furnace gas and used for energy purposes.

The emission from coke during steel production is subtracted from here and reported in 2.C.1.1 as it is explained in chapter Steel (2.C.1.1) above. So, the recalculation in 2.C.1.1. of this year has obviously influence on sector 2.C.1.4 as well.

In 2014 submission the emissions from blast furnace gas have been separated within coke consumption and reported in 1.A.1.a and 1.A.2.a sectors as blast furnace gas is used in the energy sector in the reality. So, in fact this recalculation is only a reallocation between 2.C.1.4 and 1.A.1.a and 1.A.2.a subsectors.

In 2.C.1.4 subsector, emissions from blast furnace gas are reported as recovery and are subtracted from CO<sub>2</sub>.

IEA Energy Statistics is the source of the data for both Consumption of coke in the blast furnace and the amount of recovered blast furnace gas.

Please note that 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 correlated with the consumption of coke in the blast furnace, so it might cause a changing IEF in 2.C.1.4.

**Table 4.14 Emissions from consumption of coke in blast furnace**

	BY	1990	1995	2000	2005	2008	2009	2010	2011	2012
OLD 2.C.1.4. 2013 submission CO2 emission	4024.49	2656.8	2280.8	1806.3	1633.4	1649.1	1695.3	1953.3	1947.0	
<b>SZUM Emission from Coke consumption in blast furnace (kt CO2)</b>	<b>4163.11</b>	<b>2991.5</b>	<b>2505.5</b>	<b>2016.4</b>	<b>2064.5</b>	<b>2033.3</b>	<b>1862.6</b>	<b>2177.2</b>	<b>2121.2</b>	<b>2064.3</b>
SZUM BFG = SZUM recovery in 2.C.1.4 (kt CO2)	3599.51	2586.9	2167.3	1743.9	1782.2	1717.4	1644.6	1976.6	1871.1	1871.3
SZUM emission from Coke consumption in blast furnace NOT recovered (kt CO2)	563.60	404.5	338.3	272.4	282.3	315.9	217.9	200.6	250.1	193.0
<b>2.C.1.1. Emission from Coke in Steel production</b>	<b>352.41</b>	<b>286.8</b>	<b>192.6</b>	<b>180.1</b>	<b>181.2</b>	<b>173.0</b>	<b>139.8</b>	<b>174.5</b>	<b>172.7</b>	<b>163.7</b>
<b>2.C.1.4. Emission from coke in pig iron production</b>	<b>211.20</b>	<b>117.7</b>	<b>145.6</b>	<b>92.4</b>	<b>101.2</b>	<b>142.9</b>	<b>78.1</b>	<b>26.1</b>	<b>77.5</b>	<b>29.3</b>
2.C.1.4 diff new/old %	-95%	-96%	-94%	-95%	-94%	-91%	-95%	-99%	-96%	
SZUM Coke consumption difference new/old %	3%	13%	10%	12%	26%	23%	10%	11%	9%	

#### 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 from IEA Energy statistics or directly from factories and associations.

Please find the presently available uncertainty values based on expert judgment in an aggregated way for 2.C sector in TableA7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply. In addition carbon content of steel has been verified using EU ETS annual emission report of Iron and steel production facility. The verification resulted the update of carbon content data used in calculation 2.C.1.1 from 0.5% to 1%, which is in accordance with IPCC2006. IPCC1996 states only that carbon content of steel is "below 2%".

#### 4.5.1.8 Source-specific recalculations

Recalculations are made in this sector in 2.C.1.4. subsector due to separation of recovery of blast furnace gas, in 2.C.1.2 subsector due to update of IEA Natural gas activity data for year 2011 and in 2.C.1.1 subsector due to the update of carbon content % of steel. For details and comparison table 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. Application of 2006 IPCC Guidelines is also planned.

### **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 4.15** Amount of aluminium produced (t)

	1985	BY	1986	1987	1988	1989	1990	1991	1992
Aluminium, t	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
Aluminium, t	27.88	29.65	31.91	33.47	33.67	33.71	33.64	33.85	34.59
	2002	2003	2004	2005	2006-2012				
Aluminium, t	35.29	35.04	34.35	31.78	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 4.16** CF<sub>4</sub> emission in Aluminium Production 2.C.3 sub-sector (1985-2012)

	1985	BY	1986	1987	1988	1989	1990	1991	1992
CF <sub>4</sub> , Gg	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
CF <sub>4</sub> , Gg	19.64	21.4198	22.483	21.4822	21.4139	23.047	23.6	28.4	26.7464 8
	2002	2003	2004	2005	2006-2012				
CF <sub>4</sub> , Gg	27.18524	25.376	26.9594	28.0105	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.

Please find the presently available uncertainty values based on expert judgment in an aggregated way for 2.C sector in TableA7-1 in Annex 7 of the NIR.

#### 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 greenhouse gases from sub-sectors Pulp and Paper and Food and Drink are reported using default emission factors from EMEP/EEA 2009. Guidebook.

### 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: HFCs from 2.F.1 in Level and Trend

#### 4.8.1 . General (CRF 2. F)

##### 4.8.1.1 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.

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 was further used in the past 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.

The list of F-gases and the GWP values to be used are defined in Table 1 of FCCC/2002/8.

**Table 4.17** List of F-gases and GWP values

Greenhouse gas	Chemical formula	1995 IPCC GWP
<b>Hydrofluorocarbons (HFCs)</b>		
HFC-23	CHF <sub>3</sub>	11 700
HFC-32	CH <sub>2</sub> F <sub>2</sub>	650
HFC-41	CH <sub>3</sub> F	150

HFC-43-10mee	C5H2F10	1 300
HFC-125	C2HF5	2 800
HFC-134	C2H2F4	1 000
HFC-134a	CH2FCF3	1 300
HFC-152a	C2H4F2	140
HFC-143	C2H3F3	300
HFC-143a	C2H3F3	3 800
HFC-227ea	C3HF7	2 900
HFC-236fa	C3H2F6	6 300
HFC-245ca	C3H3F5	560
<b>Perfluorocarbons</b>		
Perfluoromethane	CF4	6 500
Perfluoroethane	C2F6	9 200
Perfluoropropane	C3F8	7 000
Perfluorobutane	C4F10	7 000
Perfluorocyclobutane	c-C4F8	8 700
Perfluoropentane	C5F12	7 500
Perfluorohexane	C6F14	7 400
<b>Sulphur hexafluoride</b>		
Sulphur hexafluoride	SF6	23 900

The applicable GWP-s are determined based on the effects of greenhouse gases over a 100-year time horizon as provided by the IPCC in its second assessment report.

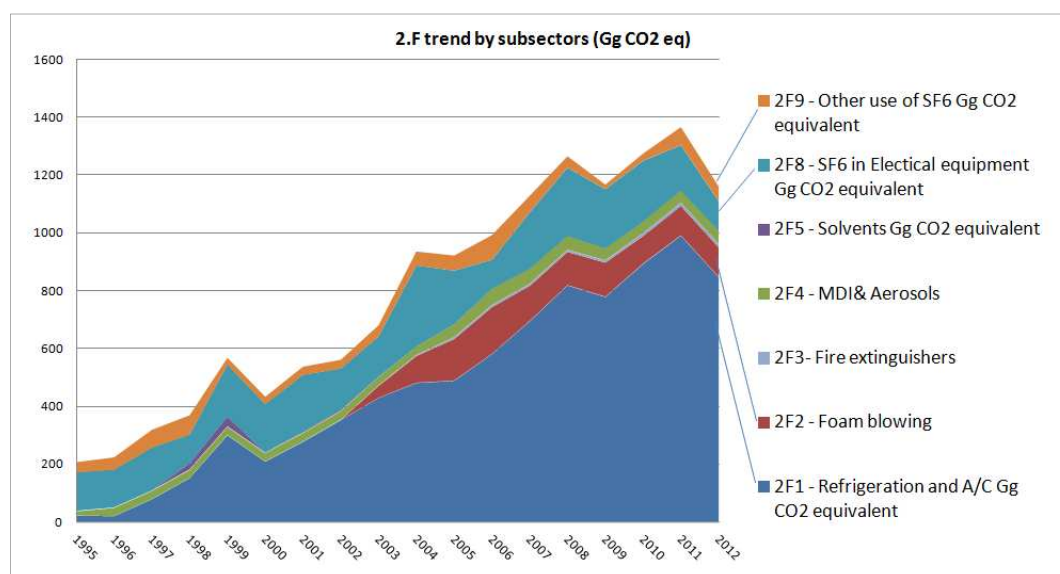
Emissions are to be reported by gas in the inventory, so the blends/preparations containing different F-gases need to be proportionated.

#### 4.8.1.2 Emission trend

Total emissions estimated from 2.F Consumption of Halocarbons and SF<sub>6</sub> were 1160Gg CO<sub>2</sub>-eq in 2012, or 24.5%% of the total industrial processes emissions compared to 0.4% in 1985-87 and 3.4% in 1995. Total sectoral emissions increased by 559% between 1995 and 2012, which was mainly due to strongly increasing emissions from the use of HFCs as substitutes for ozone depleting substance (*ODS Substitutes*). However the growing tendency seems to have stopped since 2008. Aggregated emissions decreased by 15% between 2011 and 2012.

Please note that the continuous improvement of calculation methodology causes recalculations, which might affect the trends as well. Since 2013April submission recalculations have occurred in sector 2F1 (2013October - disposal emission), 2F2-Foam blowing, 2F4-MDI. In addition, the calculation method in 2.F.8-9. SF<sub>6</sub> use categories is still Tier1 (or very similar), which means that emissions are equal (or similar) to the annual sales, so emissions are probably overestimated and the trends reflect more the situation of trading than the real trend of emissions.

Figure 4.14 shows the trend of F-gases emissions from 2.F Consumption of Halocarbons and SF<sub>6</sub> by sub-categories for the years 1995 to 2012. 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.



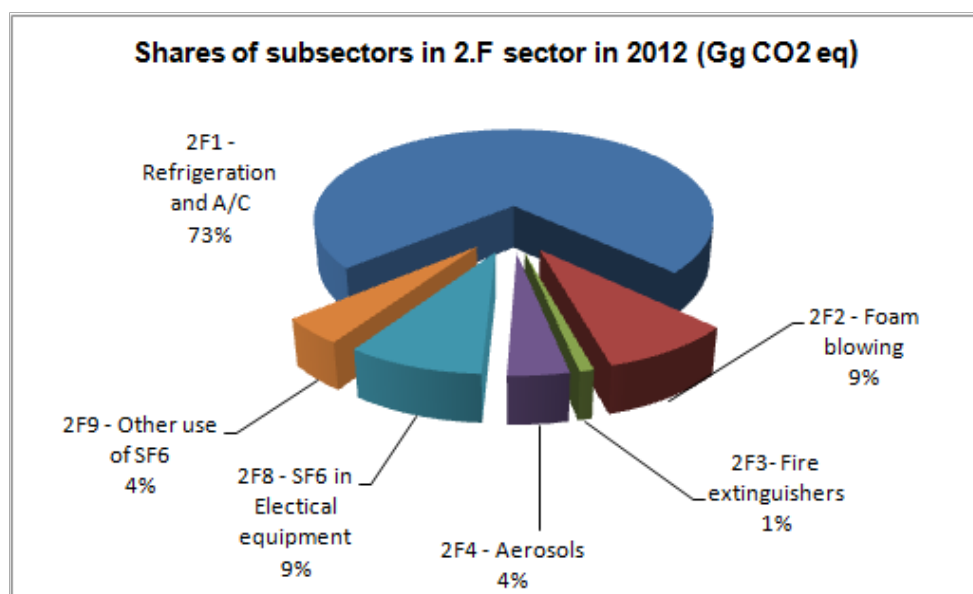
**Figure 4.14** Actual emission of F gases from sub-sector, 1995-2012 (Gg CO<sub>2</sub>-eq)

Table 4.18 shows the trend of actual emissions of F-gases by subsector and potential emission from 2.F Consumption of Halocarbons and SF<sub>6</sub> for the years 1995 to 2012. Potential emission calculation method means that annual sales of a given year (production+import-export) are reported as emissions. Actual emission method takes into account a time lag between the sales and the emissions.

**Table 4.18** Emissions in 2F by subsectors, Gg CO<sub>2</sub>-eq, (1995-2012)

	2F1 - Refrigeration and A/C	2F2 - Foam blowing	2F3- Fire extinguish ers	2F4 - MDI& Aerosols	2F5 - Solvents	2F8 - SF6 in electr. eq.	2F9 - Other use of SF6	<b>SZUM 2F Actual</b>	<b>SZUM 2F Potential</b>
<b>1995</b>	23.88	NO	NO	13.96	0.00	133.74	35.85	<b>207.44</b>	234.29
<b>1996</b>	21.58	NO	NO	27.89	0.00	131.61	43.02	<b>224.10</b>	235.79
<b>1997</b>	80.18	NO	NO	27.84	0.00	149.40	61.90	<b>319.31</b>	379.99
<b>1998</b>	152.69	NO	NO	27.77	20.91	100.76	67.40	<b>369.53</b>	477.92
<b>1999</b>	301.48	NO	NO	27.69	33.73	181.83	23.66	<b>568.40</b>	748.24
<b>2000</b>	210.29	NO	NO	28.12	0.00	169.45	25.81	<b>433.67</b>	554.79
<b>2001</b>	278.62	NO	0.58	28.61	3.92	197.10	28.92	<b>537.75</b>	694.18
<b>2002</b>	353.67	NO	0.96	28.67	3.92	143.92	30.35	<b>561.50</b>	794.04
<b>2003</b>	430.11	40.94	1.80	28.63	0.00	140.36	39.20	<b>681.04</b>	1076.20
<b>2004</b>	482.28	91.99	3.59	28.46	0.00	281.59	48.04	<b>935.95</b>	1433.40
<b>2005</b>	489.62	143.21	6.22	45.09	0.00	185.62	52.10	<b>921.87</b>	1447.27
<b>2006</b>	581.91	161.27	6.89	56.72	0.00	100.58	85.20	<b>992.57</b>	1509.08
<b>2007</b>	695.86	120.79	6.87	52.63	0.00	195.79	56.94	<b>1128.88</b>	1637.36
<b>2008</b>	819.38	114.42	6.67	49.35	0.00	236.60	38.91	<b>1265.33</b>	1829.81
<b>2009</b>	779.56	117.30	7.44	42.58	0.00	204.81	15.75	<b>1167.43</b>	1570.57
<b>2010</b>	893.58	94.98	9.53	41.72	0.00	210.26	24.67	<b>1274.75</b>	1707.74
<b>2011</b>	991.40	101.32	10.48	43.34	0.00	157.59	61.97	<b>1366.10</b>	1669.74
<b>2012</b>	848.06	101.72	10.96	46.44	0.00	103.08	50.29	<b>1160.54</b>	1454.52

In 2012, the 2.F.1 Refrigeration and Air Conditioning Equipment sub-sector accounted for 73.1% of total F-gases emissions, followed by 2.F.8 Electrical Equipment sub-sector 8.9%, 2.F.2. Foam blowing subsector 8.8%, 2.F.9 Other SF<sub>6</sub> sub-sector 4.3%, 2.F.4. Aerosols subsector 4.0 % and 2.F.3 Fire Extinguishers sub-sector 0.94%. (see Figure 4.15).



**Figure 4.15** Emission from sub-sectors of F gases in 2012, Gg CO<sub>2</sub>-eq

Table 4.19 shows actual emissions in tons by gases and the sum of the different groups of F-gases in Gg CO<sub>2</sub> eq.

**Table 4.19** Emissions in 2.F by gases , (1995-2012)

	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	SZUM HFCs actual	PFC-116, C <sub>2</sub> F <sub>6</sub>	PFC-218, C <sub>3</sub> F <sub>8</sub>	SZUM PFCs actual	SF <sub>6</sub>	SZUM SF <sub>6</sub> actual
GWP	11700	650	2800	1300	140	3800	2900	6300		9200	7000		23900	
	t	t	t	t	t	t	t	t	Gg CO <sub>2</sub> eq	t	t	Gg CO <sub>2</sub> eq	t	Gg CO <sub>2</sub> eq
1995	NO	NO	NO	27.6	NO	NO	0.7	NO	37.8	NO	NO	NO	7.1	169.6
1996	NO	NO	0.1	34.7	NO	0.1	1.4	NO	49.5	NO	NO	NO	7.3	174.6
1997	0.1	0.0	2.7	65.4	0.1	2.6	1.4	NO	107.9	NO	0.0	0.1	8.8	211.3
1998	0.2	0.3	8.3	91.9	0.2	7.9	1.4	NO	178.8	NO	0.2	22.6	7.0	168.2
1999	0.5	2.6	17.2	155.5	0.2	17.3	1.4	NO	327.2	NO	0.3	35.7	8.6	205.5
2000	0.1	1.2	17.4	90.1	0.5	17.3	1.4	NO	237.0	NO	0.2	1.4	8.2	195.3
2001	0.0	1.7	21.2	129.1	0.8	20.4	1.4	NO	310.2	0.0	0.2	1.5	9.5	226.0
2002	0.0	2.7	34.0	122.7	0.8	32.8	1.4	NO	385.2	0.0	0.3	2.1	7.3	174.3
2003	0.1	5.8	38.2	194.6	1.3	33.4	2.6	NO	499.1	0.0	0.3	2.4	7.5	179.6
2004	0.1	7.2	46.8	235.1	0.8	40.0	3.3	NO	604.4	NO	0.3	1.9	13.8	329.6
2005	0.1	7.7	44.8	301.3	0.7	36.2	7.2	NO	681.7	NO	0.3	2.4	9.9	237.7
2006	0.1	10.9	57.1	337.0	12.6	45.7	7.7	NO	804.3	0.0	0.4	2.5	7.8	185.8
2007	0.1	12.3	71.2	319.5	16.9	59.1	7.7	NO	872.6	NO	0.5	3.6	10.6	252.7
2008	0.1	15.8	81.0	370.5	0.6	64.2	7.6	NO	986.0	0.0	0.5	3.8	11.5	275.5
2009	0.2	12.6	79.6	340.5	0.5	64.4	8.0	NO	943.9	0.0	0.4	2.9	9.2	220.6

	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-152a	HFC-143a	HFC-227ea	HFC-236fa	SZUM HFCs actual	PFC-116, C <sub>2</sub> F <sub>6</sub>	PFC-218, C <sub>3</sub> F <sub>8</sub>	SZUM PFCs actual	SF <sub>6</sub>	SZUM SF <sub>6</sub> actual
<b>2010</b>	0.1	20.4	94.2	366.7	0.8	68.9	7.4	NO	<b>1038.6</b>	NO	0.2	<b>1.2</b>	9.8	<b>234.9</b>
<b>2011</b>	0.6	17.1	99.4	409.0	0.3	77.4	7.7	0.0	<b>1144.8</b>	0.0	0.2	<b>1.7</b>	9.2	<b>219.6</b>
<b>2012</b>	0.1	9.3	84.5	360.4	0.3	70.7	7.9	0.2	<b>1005.8</b>	NO	0.2	<b>1.4</b>	6.4	<b>153.4</b>

#### 4.8.1.3 Methodological issues

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 the basis of the information received from commercial and/or user companies.

Since 2009 the data provision became a legally binding obligation as 345/2009. (XII.30.) Govt. Decree entered into force prescribing that any data not reported based on 310/2008. (XII.20.) Govt. Decree (please find detailed description in the following paragraph) and needed for the preparation of the inventory should be directly reported to HMS. In present submission directly reported data of companies is used solely in 2.F.4. Aerosols and partly in 2.F.8-9. SF<sub>6</sub> use (any other data received is used for verification).

The data collection situation of F-gases is quite favorable in Hungary, because in addition to the directly applicable 842/2006/EC Regulation, Hungary has an additional Govt. Decree: 310/2008. (XII.20.). 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 ton otherwise only record keeping is needed. But the Hungarian Govt. Decree 310/2008 (XII.20) requires not only to maintain records, but also to report several data for those who handle more than 3 kg F-gases in sectors refrigeration and air-conditioning, fire, solvents and SF<sub>6</sub> use.

The institutions appointed for data collection are:

- Refrigeration, air-conditioning and heat pumps (hereinafter: RACHP) sector: Hungarian Monitoring and Certification Body (in Hungarian: OMKT; hereinafter HMBC) This institution is appointed for certification of persons required by 842/2006/EC as well and it is maintained by the Association of Cooling and Air Conditioning Businesses (HKVSZ));
- Fire: National Directorate General for Disaster Management, Ministry of the Interior (NDGDM);
- Solvents (not occurring in Hungary as far as our knowledge): National Inspectorate for Environment, Nature and Water (NIENW);
- SF<sub>6</sub> use: Hungarian Electrotechnical Association (MEE).

Although the first year of data provision was 2009, the system started to work quite slowly. But the data of 2010 and 2011 was already collected this way, and in the submission of this year it has been integrated into the calculation methods of the inventory too as it is described below in detail.

Out of the huge amount of data collected based on 310/2008.(XII.20.) Govt. Decree, the

following is applied at the moment in the inventory:

- Reported to HMBC database in sector refrigeration, air-conditioning and heat pumps:
  - import, export of bulk chemicals,
  - intended use (for new equipment or for recharge/service).
- Reported to Hungarian Electrotechnical Association (MEE):
  - import, export of bulk chemicals.

Please find more details in the sector specific subchapters below.

Since 2013 April submission the following changes occurred within 2.F sector:

- „MS Support Project” (described in chapter 4.8.2.3) results:
  - QC in 2.F.1
  - QC and recalculation in 2.F.2.
  - QC in 2.F.3.
  - QC and recalculation in 2.F.4. taking into account import in products as required by review in 2012
- recalculation of disposal emissions in 2.F.1 in 2013 October submission due to potential problem identified during 2013 review

#### **4.8.1.4 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.

#### **4.8.1.5 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. Instead of using import quantity data received from VPOP, we changed to using data obtained directly from users and industry associations appointed by 310/2006 Govt. Decree for data collection. Thereby the associated uncertainty was significantly reduced. The company for manufacturing household refrigerators operates a quality assurance system of the ISO 9000 series.

The presently available values can be found in Table A7-1 in Annex 7 of the NIR.

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

General QA/QC procedures apply. In addition continuous efforts are taken to explore data sources for verification. Results are included in the descriptions of the subsectors above if relevant.

In 2013 Hungary took part of the “*Project on assistance to Member States as regards reporting requirements under the Kyoto Protocol*” regarding the issue of F-gases. Within this project 2.F.1-2.F.4 sectors have been reviewed by external expert and recalculations are made in 2.F.2 and 2.F.4 sectors based on the recommendations received. For details, please see the relevant subchapters below.

#### 4.8.1.7 Source-specific planned improvements

Planned improvements are detailed below by sub-sectors.

### 4.8.2 Refrigeration and Air Conditioning Equipment (CRF 2.F.1)

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

The use of HFCs started in 1992, first in household refrigerators. However the use of HFC-s as a refrigerant in household refrigerators is declining (for example the only Hungarian producer of household refrigerators uses exclusively R600 (isobutane)), Hungary still reports all the refrigeration and air-conditioning HFC emissions in an aggregated way under Domestic refrigeration subcategory. C<sub>3</sub>F<sub>8</sub> (PFC) emissions within refrigeration and air-conditioning sector are reported in an aggregated way under Commercial refrigeration subcategory. It is a planned improvement to review this allocation and to disaggregate emissions at least into refrigeration, stationary and mobile air conditioning subcategories.

The trend of emissions in sector 2.F.1. is included in Table 4.18.

All 2.F.1 subcategories, all years (from 1992-2012), and all HFCs, PFCs covered by UNFCCC are covered. (SF<sub>6</sub> is included in 2.F.8-9.sectors of course).

Coverage of all gases and all 2.F.1. subsectors is ensured by the fact, that the scope of Govt.Decree 310/2008. is the same as the scope of 842/2006/EC Regulation of the EU on F-gases, which is the same as the UNFCCC.

Coverage of years is ensured by the fact that the former Ministry of Environment and Water collected HFC/PFC import-export data together with annual sales data of ozone depleting substances directly from the wholesaler companies since 1992. By the entry into force of Govt. Decree 310/2008 (XII. 20.) the task of data collection in RACHP sector was transferred to the Hungarian Monitoring and Certification Body (HMCB) as it is described above.

Although in the case of top-down approach it is not required to use the structure of CRF Table, we have included our results. Please find the explanations of the values inserted into the appropriate cells of the CRF below, following the structure of the CRF:

ACTIVITY DATA <i>Amount of fluid</i>		
Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning
<i>new% * Annual sales</i>  <i>new% is the proportion of the use intended to charge new equipment</i>	FOR INFORMATION ONLY! (Not used in the calculations, since it is not needed for top-down approach); Accumulation of "Amount of fluid filled in new" of the year n years before n= lifetime = 12 (from GPG Table 3.22)	Amount of fluid filled in new 12 year before
EMISSIONS		
From manufacturing	From stocks	From disposal
k % of Amount of fluid filled in new <i>k= manufacturing/initial emission factor= 1 % from GPG Table 3.22</i>	Annual sales - Amount of fluid filled in new manufactured products (Total charge of new equipment)	Remaining in products at decommissioning – intentional destruction
IMPLIED EMISSION FACTORS		
Product manufacturing factor	Product life factor	Disposal loss factor
From manufacturing / Filled into new manufactured products	From stocks/ In operating systems (average annual stocks)	From disposal/ Remaining in products at decommissioning

#### 4.8.2.1 Methodological issues

Annual sales data is calculated as import-export of bulk chemicals. Documented, consistent time series of import-export exists since 1992, thank to the fact that the former Ministry for Environment, Nature and Water collected this data together with annual sales data of ozone depleting substances directly from the wholesaler companies. HMS has always been in a strong cooperation with the Ministry, so this data was used for the calculation of inventory, together with the additional information collected directly by HMS when it was necessary.

By entry into force of Govt.Decree 310/2008 (XII.20.) the task of data collection was transferred to the Hungarian Monitoring Body for Certification as it is described in 2.F.General chapter above. HMS receives the data needed from the HMBC database for the preparation of the inventory still through the ministry responsible for environment (Ministry for Rural Development).

Consistency of the time series is ensured by the fact that annual sales data is collected by wholesale companies. It was checked that the same companies report to the HMBC database too (except for the natural changes of the market, like cessations and entries of course)

The source of the data is the database set up by 310/2008.(XII.20.) maintained by the Hungarian Monitoring and Certification Body (in Hungarian: OMKT; hereinafter HMBC). This institution is appointed for certification of persons required by 842/2006/EC ("EU F-gas Regulation") as well and it is maintained by the Association of Cooling and Air Conditioning Businesses (HKVSZ)). The HMBC database contains plenty of information out of which the following Table summarizes the application of several data within the calculation in 2.F.1 sector.

HMBC database content (required by Govt.Decree 310/2008.)	Data provider	Application of the data for HU UNFCCC Inventory in 2.F.1. sector
Information on import, export	Wholesaler companies	Potential, Actual Top-down
Information on use	Certified companies (842/2006/EC requirement to maintain a logbook on the use of the stock of the refrigerant (whether they have used it for installation of new equipment or for service/recharge)	Actual Top-down (determination of quantity used for new/recharge)
Information on recovery and destruction		Determination of proportions of different F- gas types within "amount destroyed " in Actual top-down calculation
Information on refrigerant circuits above 3 kg (leaked/recharged quantity – <i>not complete</i> )	Certified persons (on the result of annual leakage checks required by 842/2006/EC)	<i>(not yet)</i>

Unfortunately the latter section of the database has not yet reached the adequate completeness, so it cannot be used at the moment neither for bottom-up approach, nor for verification.

Of course, the blends/preparations are proportionated based on the appropriate HFC/PFC/other gas percentage content.

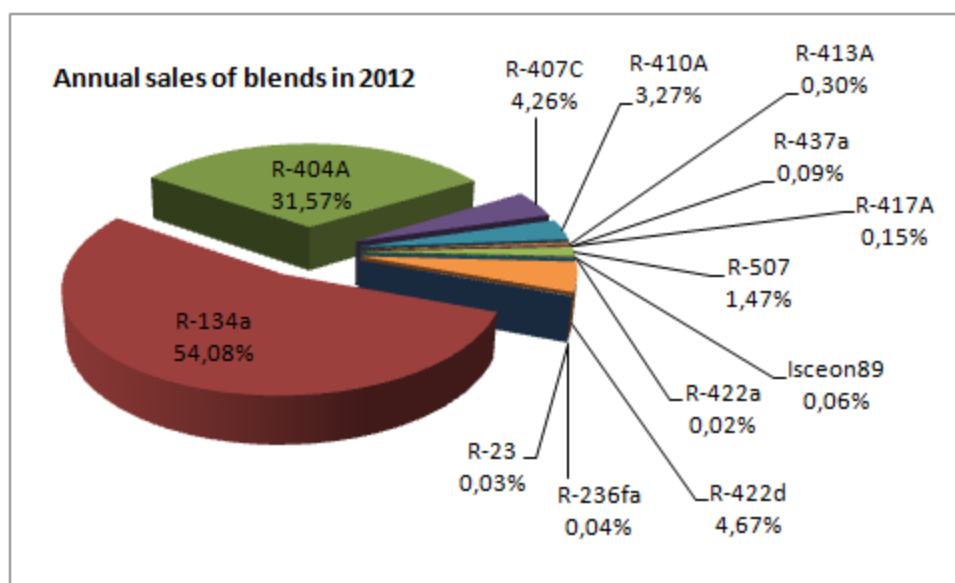
Further, detailed information on HMBC database is available at:

UNEP-ECA Network meeting 2011, Budapest:  
<http://www.unep.org/ozonaction/ecanetwork/Activities2011/ThematicmeetinginBudapest/tabid/56112/Default.aspx>

and HU case study in Preparatory study for the F-gas Review, Schwarz et al. (2011) Öko-Recherche GmbH) available at :

[http://ec.europa.eu/clima/policies/f-gas/docs/2011\\_study\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_en.pdf)

Hungary imported 815.5 t F gases in 2012 and exported 214.4 t within the refrigeration and air conditioning sector. The most used gases are the HFC-134a, R-404A and R407C. (see Figure 4.16)



**Figure 4.16** Annual sales of blends containing F gases in 2.F.1 in 2012, Gg CO<sub>2</sub>-eq

Hungary uses top-down approach, where quantities of chemical sales are used rather than emission factors.

The method described in NIRs of earlier years (namely emissions are equal to the recharged quantity) was in fact corresponding to the top-down method:

#### **GPG2000 EQUATION 3.40**

Emissions = (Annual Sales of New Refrigerant) – (Total Charge of New Equipment)  
 + (Original Total Charge of Retiring Equipment) – (Amount of Intentional Destruction)

Part 1. of Eq. 3.40:

(Annual Sales of New Refrigerant) – (Total Charge of New Equipment)  
 = Annual sales – (Annual sales \* %used to charge new equipment)  
 = Annual sales \* (100% - %used to charge new equipment)  
 = Annual sales \* (%used to recharge) (=“old description of HU method”)

Please see the detailed description of this part of the calculation in Operational emissions subchapter below.

The deficiencies of the calculation method of HU used to be the lack of estimation of disposal emissions and expression of manufacturing emission.

The latter was recommended by the annual review report received in year 2012, and thus reporting of manufacturing emissions have been included. The description of this part of the calculation is included in Manufacturing emissions subchapter below.

The reporting of disposal emissions (e.g. the part 2. of Eq. 3.40: + (Original Total Charge of Retiring Equipment) – (Amount of Intentional Destruction)) was included in 2012 October submission required by the review in September 2012. 2012 and an additional recalculation was recommended by the review in 2013. The description of this part of the calculation is included in Disposal emissions subchapter below.

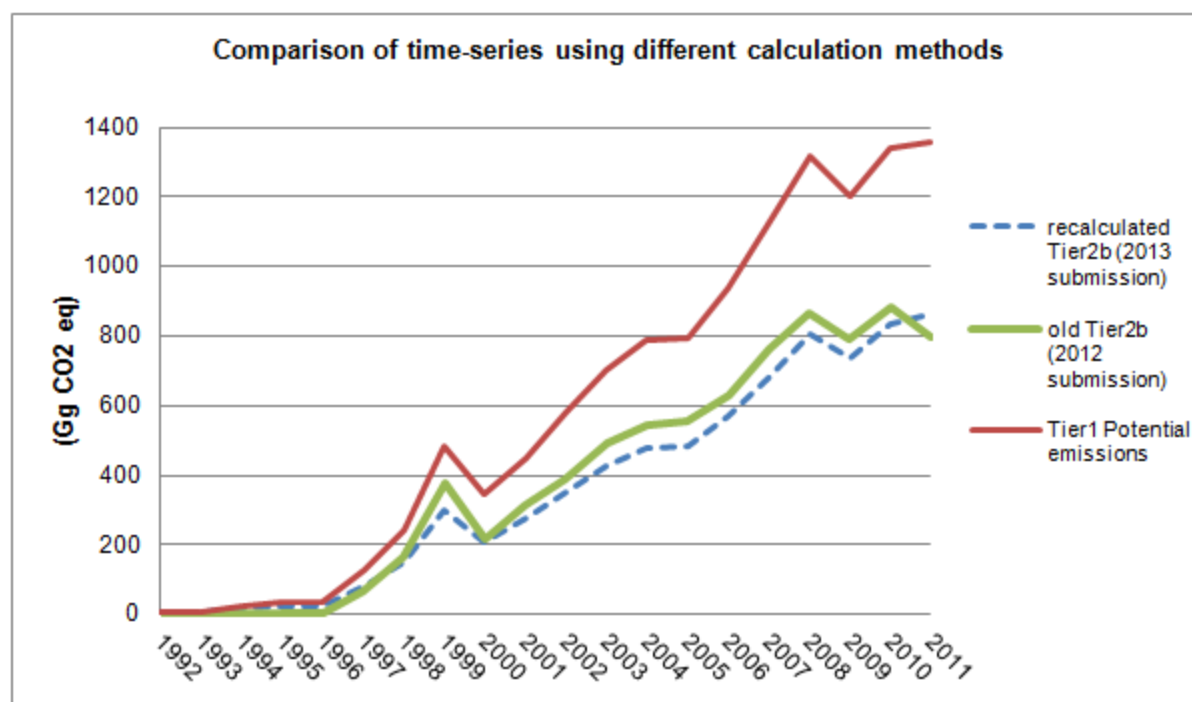
### Operational emissions

Before 2013 submission, expert judgment and/or the wholesalers own judgment was used to estimate new/recharge% proportions. In this year data on intended use (new/recharge % ) from the HMBC database became available from year 2010. Using the average of 2010 and 2011 new / recharge % -s were recalculated. The average of 2010 and 2011 data on intended use resulted in the following values by gas:

**Table 4.20** Average of 2010 and 2011 data of intended use by gas

	new %	recharge%
HFC 23	53.60%	46.40%
HFC 32	45.67%	54.33%
HFC 125	38.84%	61.16%
<b>HFC 134a</b>	<b>35.41%</b>	64.59%
HFC 143a	43.76%	56.24%
HFC 152a	100.00%	0.00%
HFC-236fa	100.00%	0.00%
PFC116. CF4	34.49%	65.51%
PFC218. C3F8	19.15%	80.85%

The application of new results presented in the Table caused the recalculation of the whole time-series. The trends of emissions using different calculation methodologies are presented in the following Figure:



**Figure 4.17** Comparison of time-series using different calculation methods

As it is possible to see, the recalculation does not result a significant change, so the expert judgment used in earlier years to estimate the intended use proportion seems to be justified.

The use of data on intended use extracted from HMCB database by gas allows the determination of a more accurate and transparent results because:

- it is based on real data provided by the wholesaler companies into the HMCB database instead of expert and/or the wholesalers own judgment;
- the source of the data is a traceable electronic database (HMCB) set up by a legally binding data provision requirement;
- the percentages (data on intended use) by gas are more accurate than by company.

The following Table presents the calculation of operational emission in detail for HFC134a for several years as an example:

**Table 4.21** Example of calculation of operational emissions

	1992	1995	2000	2005	2010	2011	2012
Annual sales of HFC 134a (t)	4.00	28.29	110.21	260.42	371.89	366.81	357.1
Amount of fluid filled in new manufactured products = 35.41% * Annual sales (t)	1.42	10.02	39.03	92.23	131.70	129.90	126.46
Actual emissions from stocks= Annual sales - Amount of fluid filled in new manufactured products (t)	2.58	18.27	71.18	168.19	240.18	236.90	230.63

#### Manufacturing emissions

However the calculation of manufacturing emissions is not required in Top-down approach it is possible to separate a certain amount in order to express manufacturing emissions separately. Hungary follows this practice as in the review report of year 2012 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.

Total Charge of new equipment do not contain the amount emitted during manufacturing (Amount used for new equipment = 1% manufacturing emission + 99% Total charge of new equipment) in order to avoid double counting of manufacturing emissions, as it was suggested by the ERT during the review and accepted for the resubmission of time series in 2013 October.

#### Disposal emissions

This part of the calculation is meant to express the following part of Eq. 3.40. of the GPG (for Top down approach):

$$+ (\text{Original Total Charge of Retiring Equipment}) - (\text{Amount of Intentional Destruction})$$

During the review in September 2012 it was recommended that Hungary estimates the actual emissions of HFCs from refrigeration and air conditioning equipment from disposal. Following the recommendation of the ERT, Hungary estimated for the first time the disposal emissions within 2.F.1. Refrigeration and air-conditioning sector using default values from the GPG Table 3.22 in 2012 October submission, using 12 years as lifetime (n), 90% for remainder (y) and 80% as recovery efficiency (x).

During 2013 review the ERT required to assume a default recovery efficiency of 0%, if a country-specific recovery efficiency cannot be justified,

Unfortunately the presently available data regarding recovery (especially recycling and regeneration) in Hungary are not sufficient for the elaboration of a country specific recovery efficiency factor. Recovery is happening in Hungary since both 842/2006/EC and 310/2008.Govt.Decree are in force directly imposing this requirement on Hungarian companies in addition to the implementation of WEEE Directive and Directive 2000/53/EC on end-of life vehicles (ELV Directive) which indirectly improves the recovery efficiency of refrigerants as well. Unfortunately these objectives regarding recovery of WEEE and ELV are not applicable yet in our case as no data is available on the share of retired equipment containing fluorinated gases and the type of treatment of the gases after recovery.

So, Hungary is yet not able to justify a country specific recovery efficiency factor due to lack of data. Therefore we have applied 0% recovery efficiency as recommended by the ERT and determined the amount of intentional destruction.

#### *Original Total Charge of Retiring Equipment*

Determination of Original Total Charge of Retiring Equipment is the same as in the case of 2013April submission, e.g. the Total Charge of new equipment lifetime years ago.

The same lifetime = 12 years default value has been applied, which is suggested by GPG Chapter 3.7.4.1 (Choice of activity data Top-down):

*„Original Total Charge of Retiring Equipment can be estimated using the same sources as are used for Total Charge of New Equipment. In this case, however, the data are historical, coming from the year in which this year's retiring equipment was built. That year is determined by subtracting the lifetime of the equipment from the current year. (...) The default product lifetime value for air-conditioning and refrigeration equipment as a whole, for use when data for specific types of equipment are not available, is 10-15 years.”*

#### *Amount of Intentional Destruction*

Hungarian Govt.Decree 440/2012.( XII. 29.) (replacing Govt.Decree 164/2003. (X. 18.)) requires the reporting production, transport, treatment (including destruction) of wastes above 100 kg (in the case of hazardous waste) into National Environmental Information System (OKIR-HIR) database. This database is primarily used by the Regional Inspectorates for Environment, Nature and Water for inspection, but GHG Division of the Hungarian Meteorological Service has also full access. Several aggregated time-series (including aggregated amount of wastes by EWC code) are also publicly available at: [www.okir.kvvm.hu](http://www.okir.kvvm.hu).

Commission Decision 2000/532/EC establishing European List of Waste has been implemented in Hungary by Govt.Decree 16/2001. (VII.18.), which is replaced now by Govt.Decree 72/2013. (VIII. 27.). The consolidated version of all this regulations contains the following EWC code: 14 06 waste organic solvents, refrigerants and foam/aerosol propellants - 14 06 01\* chlorofluorocarbons, HCFC, HFC

Types of treatment of wastes are classified by Annex I to Directive 2008/98/EC on waste, including: D 10 Incineration on land

Amounts of EWC140601 treated D10 (reported by waste incinerators) extracted from the database by year is presented in the following Table in metric tons together with the calculated share of HFC within EWC140601 and data sources.

HMCB database contains also information regarding recovery, but unfortunately there are only amounts recovered and sold for recycling, reclamation or destruction by (several)

certified companies. Although the data in HMCB database is not complete, it is very detailed. Therefore the share of the specific HFC/PFC gases might be determined, as quantities are reported by blend.

**Table 4.22** Amounts of destroyed EWC140601\* and Amounts of HFC/PFC intentional destruction

	EWC140601 (t) D10 treatment Source: OKIR-HIR	Share of HFC/PFC within EWC140601	Source of the share of HFC/PFC within EWC140601	Total (t) HFC/PFC intentional destruction
<b>2004</b>	1.82	0		0
<b>2005</b>	1.20	0		0
<b>2006</b>	8.42	0		0
<b>2007</b>	15.25	0		0
<b>2008</b>	13.22	0		0
<b>2009</b>	21.12	0		0
<b>2010</b>	14.95	61.44%	Average of the share of HFC/PFC within sold quantities by certified companies reported into HMCB database.	9.18
<b>2011</b>	12.02	61.44%		7.38
<b>2012</b>	17.03	92.53%	Data reported by HU destruction facilities required by Art.27 of 1005/2009/EC on ODS	15.75

#### 4.8.2.2 Source specific recalculations

After the recalculation due to inclusion of manufacturing emissions in 2012 April submission and the recalculation due to inclusion of disposal emissions in 2012 October submission, in 2013 April submission the time series was recalculated due to application of new data of intended use. In 2013 October submission disposal emissions have again been recalculated due to the recommendation of the ERT in 2013 review. The new method is described in detail above.

For 2014 submission there are no recalculations in this subsector.

#### 4.8.2.3 Source specific QA/QC activities and planned improvements and uncertainties

Since 2012 several consultations have been organized with external experts and experts from the HMCB.

In order to acquire further opinions of external experts, the HU emission calculation method in 2.F.1. sector was presented in the „Refrigerants inventory” section of the 8th International Conference on Compressors and Coolants ([http://szchkt.org/a/conf/conference\\_sessions/6?locale=en\\_GB](http://szchkt.org/a/conf/conference_sessions/6?locale=en_GB)).

No findings or recommendations have been received during these occasions.

In 2013 HU had the possibility to take part in the "MS Support Project" organized by EU DG Climate Action aiming to assist several EU Member States in the effective implementation of the reporting requirements under the Kyoto Protocol to the UNFCCC by providing technical assistance and capacity building support. A Wikidot site (<http://mskp-support.wikidot.com/legal:public>) have also been initiated where several suggestions of experts have been posted. During the project, the calculation method was reviewed also in the case of 2.F.1. RAC sector by external expert. The method was evaluated as "solid" and no errors or gaps have been identified. Recommendations were received for the

disaggregation of emission into domestic, industrial and mobile subsectors. Unfortunately the disaggregation of emission within RACHP sector is not yet performed, but it is still a planned improvement, because the potential problem identified in this subsector during 2013 review (recalculation of disposal emissions) had to have priority this year and it would not influence completeness anyway.

In addition it is planned to further refine the presently used methodology by acquiring expert judgments on the trend of intended use (new/recharge quantities) in earlier years. Investigation of the implementation of EU MAC directive is also planned in addition to the implementation of 2006 IPCC Guidelines.

Uncertainties are estimated based on expert judgment in an aggregated way for HFC emissions and PFC emissions, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

### **4.8.3 Foam Blowing (CRF sector 2.F.2)**

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

Following the recommendation of the ERT during the 2012 review, Hungary estimated for the first time the actual emissions from closed-cell foams imported into the country and emissions from manufacturing too in 2012 October submission. Suggestion received during the EU MS Support Project (described in chapter 4.8.2.3) has been implemented in 2014 submission.

#### **4.8.3.1 Methodological issues**

##### Actual emissions

TIER 2 method is applied using activity data derived from PRODCOM statistics and emission factors from GPG.

Open cell foams are accounted in sub-category soft foam using eq.3.37 from the GPG and closed cell foams are accounted in sub-category hard foam using eq.3.38 of the GPG. Within the latter category both XPS and PUR hard foams are accounted.

Please note that no decommissioning losses and destroyed quantity is reported because no product have yet reached the estimated end of lifetime and no specific information is available on any destructed quantity or recycling technology.

Decision tree 3.14 of the GPG was followed. As no „data from global model” is available, „national activity data” was collected. The „national activity data” is derived from country-level statistics on import-export and domestic production (EUROStat - PRODCOM) of foam products. So, the inclusion of actual emissions from closed-cell foams imported into the country was performed by complete change of activity data source in subsector 2.F.2.

The level of disaggregation of PRODCOM statistics offer the possibility of disaggregation of activity data into two types of foam (XPS and PUR), while „country specific emission parameters” are not available at the moment, so Box2 of decision tree 3.14 has been followed:

*„Calculate emissions by substance and foam type, using national data, disaggregated default parameters, and the Tier 2 equation, incorporating end of life data if available”.*

The change resulted a significant (several magnitude level) increase of emissions within the 2.F.2. subsector and it causes 8-24% change compared to the old time series of the whole 2.F.sector.

#### *Activity data*

As it is stated in both Guidelines and NIRs of other parties: „it is extremely difficult to collect activity data...” Indeed, no direct data or statistics are available on the HFCs imported in products, neither on the amount of HFCs present in products. So, there was only the possibility to start from the viewpoint of the foam products, as it was discovered that in fact PRODCOM statistics (Statistics on the production of manufactured goods published on the website of EUROStat and Hungarian Central Statistical Office) contain both import-export and production data of two foam types.

These are: 22214120 - Cellular plates, sheet, film, foil and strip of polymers of styrene (containing XPS) and 22214150 - Cellular plates, sheets, film, foil and strip of polyurethanes (PUR) .

In order to get the amount of HFC blown into foam products, the percentage of blowing agent within foam products, proportion of HFCs within foam blowing agents and proportion of type of HFC is also needed, as it follows:

**Chemical used in Foam Manufacture** (HFC filled in new products) = domestic production of year t of foam product (t) \* blowing agent/ foam type (%) \* HFC blowing agent / all blowing agents (%) \* HFC-type / all HFC (%)

(**Chemical used in Foam Manufacture** data is to be multiplied by “first year loss” EF in order to calculate the **emissions from manufacturing**.)

**Chemical emitted during the lifetime of closed cell foams** (HFC charged into the product) = production+import-export of the foam type (t) \* blowing agent/ foam type (%) \* HFC blowing agent / all blowing agents (%) \* HFC-type / all HFC (%)

(**Chemical emitted during the lifetime of closed cell foams** data is to be accumulated as many years as the lifetime of the foam product and to be multiplied by “annual loss”EF in order to calculate the **emissions from stocks**.)

In this way **Chemical used in foam manufacture** and **Chemical emitted during the lifetime of closed cell foams** required by eq. 3.38 of the GPG has been expressed, so default EF-s from Table 3.17 and 3.18 could be used. In this method both the amounts imported in bulk (*Chemical used in foam manufacture*) and in products (within *Chemical emitted during the lifetime*) are accounted. The double usage of statistical data of foam production does not result double count in emissions, since in the first case it is used to determine the emissions from manufacturing occurred in Hungary even if the product is exported and in the second case it is needed to determine the amount of foam products remaining in the country responsible for the emissions from stocks.

The following table summarizes the values and their references used in the calculation:

	XPS	PUR	Reference
domestic production of year t of foam product (t)	Prodcom Statistics		<a href="http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database">http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database</a>
production+import-export of the foam type (t)			
blowing agent/ foam type (%)	6%	8%	Revised IPCC1996 page2.59 (6-15%) and IPCC/TEAP study (please see References)

HFC blowing agent / all blowing agents (%)	40% and decreasing <b>until 20%</b>	20% and decreasing <b>until 10%</b>	DG Climate F-gases Reg.Review Study and IPCC/TEAP study (please see References) and suggestion received during EU MS Support Project
--	--	--	--

Within PRODCOM 22214120 polystyrene foams category, only XPS (extruded polystyrene) type foam might be blown with HFCs. The proportion of XPS foam within polystyrene foams in the Hungarian market is estimated to be 10% by MEPS (Hungarian Association of EPS Insulating Foam Producers) and another expert architect.

PRODCOM data of PUR production of 2005 to 2008 and XPS production data of 2004-5 was averaged in order to avoid negative production+import-export values in the years 2006-8 and to reflect better the trend. (Production data of the mentioned years are summed and divided by number of years).

HFC are used as blowing agent in foams mainly after 2003 as substitutes of ODS after the ban of CFCs and HCFCs under Montreal Protocol. Nowadays also HFCs are substituted by materials with less GWP (CO<sub>2</sub>, Hydrocarbons, HFO, etc.) The background study of F-gases Regulation Review of DG Climate states the % of HFCs among the blowing agents is 40% for XPS and 20% for PUR between 2003-2011.

HFC use in foam blowing started in 2003 based on data reported by the intermediate material producer company (BASF).

The DG Climate study estimated that the final year of significant HFC use in foam blowing would be in 2011. However, our assumption for Hungary is 2015 (instead of 2011) based on suggestion of the IPCC/TEAP study, which seemed more realistic.

During the EU MS Support Project (described in chapter 4.8.2.3) the expert noted that the elimination of HFC blowing agent by 2015 is still not realistic and suggested to apply 20% for XPS foams and 10% for PUR foams after 2011 as well. HFC emissions of year 2011 have been recalculated based on this suggestion in sector 2.F.2.Foam.

**Table 4.23** Change in proportions of HFC foam blowing agents applied by calculation in 2.F.2

		2007	2008	2009	2010	2011	2012	2013	2014	2015
OLD 2013 submission % of HFC blowing agent usage/All blowing agent usage in the case of	XPS products	35.6	31.1	26.7	22.2	17.8	13.3	8.9	4.4	0.0
	PUR products	17.8	15.6	13.3	11.1	8.9	6.7	4.4	2.2	0.0
NEW 2014 submission % of HFC blowing agent usage/All blowing agent usage in the case of	XPS products	35.6	31.1	26.7	22.2	20.0	20.0	20.0	20.0	20.0
	PUR products	17.8	15.6	13.3	11.1	10.0	10.0	10.0	10.0	10.0

This change resulted 5% increase of emissions in year 2011. Please find comparison table in chapter 10.

The proportion of the different types of HFCs is based on the historical data reported by the intermediate material producer company (BASF). The average result is 10% HFC-227a and 90% HFC-134a.

The proportion of soft foams and hard foams within PUR foams is also based on the historical data reported by the intermediate material producer company (BASF). The average result is: 10% soft foam and 90% hard foam. All soft foam is accounted as open cell foam (using eq. 3.37. of GPG) and all hard foam is accounted as closed cell foam (using eq.3.38 of GPG).

Please note that in addition to the above mentioned method, also a directly reported experimental usage of HFC-152a solely in the years 2006 and 2007 is included within the soft foam subcategory.

#### *Emission factors*

Default emission factors from Table 3.18 of the GPG are used for XPS:

lifetime= 50 years

first year loss= 40%

annual loss= 3%

General default emission factors from Table 3.17 of the GPG are used for PUR as the proportion of the different types of PUR foams is not known:

lifetime=20 years

first year loss= 10%

annual loss= 4.5%

In the case of soft foams (all accounted as open-cell foam) equation 3.37. of GPG is used, so ALL the filled amount is emitted during manufacture.

Please note that the implied EF (in CRF) is changing through the years due to the fact that EF of the GPG is determined by foam type, while IEF in the CRF is determined by HFC type.

#### Potential emissions

Potential emission = production + import (including "in product") - export (including "in product") - destruction

No destructed quantity is subtracted at the moment as no product have yet reached the estimated end of lifetime and no specific information is available on any destructed quantity or recycling technology in Hungary.

Please note that the reason for the particular situation that towards the end of the time series the potential emission becomes lower than the actual one is that the calculation method of potential emission *"DOES NOT take into account accumulation or possible release of chemical"* e.g. *"the time lag between consumption and emission"*(GPG). So, in the case of foams, potential emissions are higher in the beginning of the time series (when the "bank is built"), while actual emissions became higher when the emissions from the accumulation of the bank become higher than the annual addition to the bank.

#### **4.8.3.2 Source specific recalculations, QA/QC activities, uncertainties and planned improvements**

In addition to general QA/QC procedures this sector has also been reviewed during the "EU MS support Project" (described in chapter 4.8.2.3). Several findings of the review have been implemented resulting recalculation in 2014 submission. Please find the comparison table in

chapter 10.3 of the NIR.

Uncertainties are estimated based on expert judgment in an aggregated way for all HFC emissions, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

It is a planned improvement and also a further recommendation of “MS Support Project” to get in touch directly with producers and to verify whether HFC blowing agents have been used in Hungary at all, the country specific proportion of foam types and HFC types used. Application of 2006 IPCC Guidelines is also planned.

#### **4.8.4 Fire Extinguishers (CRF sector 2.F.3)**

Emitted gases: HFC 125, HFC-227ea

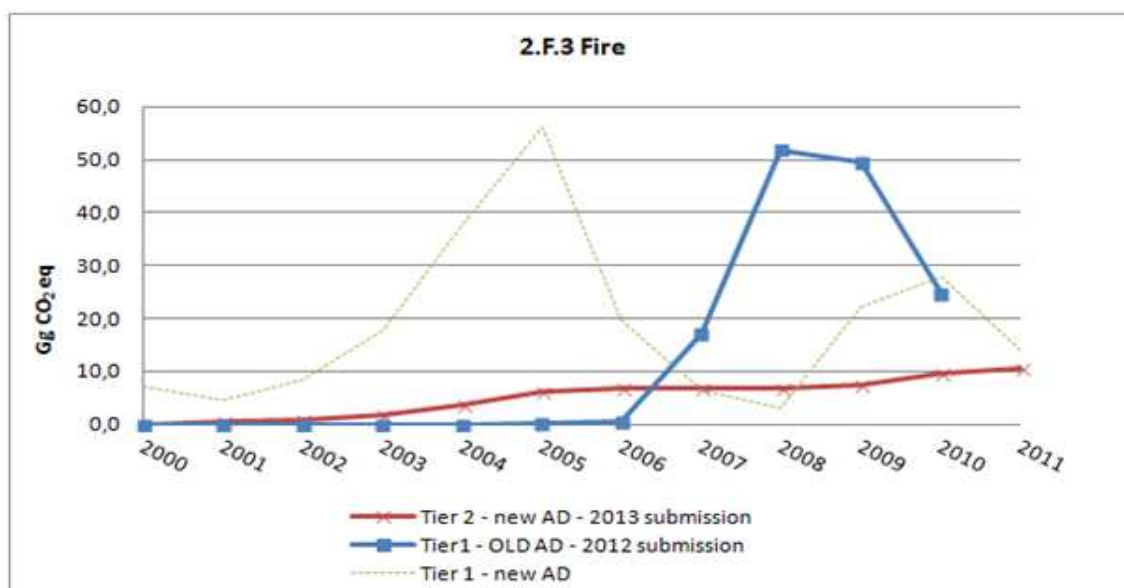
##### **4.8.4.1 Methodological issues**

Until submission of year 2013, activity data reported by several companies working within the fire protection sector has been used. Since 2013 submission, the activity data has been changed to the annual data on installed fire protection equipments collected by the Fire Protection Department of the National Directorate General for Disaster Management, Ministry of the Interior (NDGDM) as part of the yearly national statistical data collection program (OSAP). This new activity data is available from 2000 and ensures the full coverage of the country. In addition it includes the amount of import in products; however it is not possible to separate from import in bulk.

In addition the time series were recalculated using Tier 2 method. In the case of Tier 2 method “the time-lag between consumption and emission is accounted” (GPG2000), so the emission is not as high as the consumption of the given year, but it is distributed during the (default, average) lifetime of the equipments. The consumptions of the years are accumulated as a “bank”, and emissions of a given year is calculated as a certain (default) percent of this “bank”. So, the strong decrease of the emissions at the moment is only apparent as the accumulated bank might cause higher emissions in later years.

The following default EF-s have been applied:

<b>T2</b>	<b>GPG2000 chapter 3.7.6.</b>
Annual operational emission % per installed base	5%
Lifetime years	10
Recovery at the end of lifetime %	85%



**Figure 4.18** Trends of emissions using different methods in sector 2.F.3 Fire

Trend of emissions in 2.F.3 subsector is included in Table 4.18.

#### 4.8.4.2 Recalculations, QA/QC activities, uncertainties and planned improvement

There were no recalculations in this subsector in 2014 submission.

In addition to general QA/QC procedures this sector has also been reviewed during the “EU MS support Project” (described in chapter 4.8.2.3) and no findings have been identified.

Uncertainties are estimated based on expert judgment in an aggregated way for all HFC emissions, and the presently available values can be found in Table A7-1 in Annex 7 of the NIR.

Application of 2006 IPCC Guidelines is planned.

#### 4.8.5 Aerosols and Metered Dose Inhalers (CRF sector 2.F.4)

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.

The time series have been recalculated in 2014 submission using Tier 2 method applying Eq.3.35 and default emission factor of 50% from GPG, which “means that half of the chemical charge escapes within the first year and the remaining charge escapes during the second year” (chapter 3.7.1. of the GPG).

In addition new calculation method is applied in MDI subsector suggested by the expert of EU MS Support Project organized by DG Climate Action (described in chapter 4.8.2.3). This new method accounts also for emissions from imported products instead of the method applied before, that takes into account only domestically produced MDI-s.

Trend of emissions in 2.F.4 subsector is included in Table 4.18.

##### 4.8.5.1 Methodological issues

Method suggested by expert of the MS Support Project (published at Wikidot site of the Project):

*“The assumptions are totally in line with the projections included in IPCC/TEAP Special report on Medical aerosols.*

*As for medical aerosols, F-gases are today only used in Metered-Dose Inhalers (MDIs), not in nebulizers. MDIs are almost exclusively applied for the treatment of asthma and COPD (Chronic Obstructive Pulmonary Disease).*

*Types of F-gases: Only two types of HFCs are used in MDIs: HFC-134a and HFC-227ea.*

*Charge: The typical charge contained in each product (10 ml) ranges at 12 grams of HFC-134a and at 14 grams of HFC-227ea (expert estimate).*

*Reference for example: 2012 NIR Germany, p. 351: “0.15 g per 10 ml inhaler”.*

*Parameters:*

*The use of HFCs in MDIs in a particular country depends on the following aspects:*

- Population
- Prevalence of asthma in the country: Country-specific information is provided by the Global Initiative for Asthma (GINA).
- Relation of treatment methods: MDIs/ DPIs (Dry-Powder Inhalers): DPIs do not contain F-gases, but are also used for asthma treatment and hence partly cover the demand for medication. Market research institutes might be able to provide information on annual sales of MDIs and DPIs in a country.
- Data on the total quantities and the share of the two types of HFCs used in MDIs are available from Germany for the year 2010 and could be used as a benchmark: 210 tons of HFCs (195 t HFC-134a; 15 t HFC-227ea; ca. 93%/7%).

*Approach: If inventory compilers cannot get support from pharmaceutical companies or relevant associations for detailed market survey, a different approach which relies on the German data as a benchmark is suggested (also used in EU model AnaFgas):*

*Step 1: Multiply the (1) population by (2) prevalence and by (3) MDI share.*

*Example Spain: 47,021,000 million x 5.9% x 80% = 2.22 million.*

*Step 2: Compare the result to the German figure:*

*82,500,000 million x 6.9% x 50% = 2.85 million.*

*Step 3: Apply the coefficient 2.22 million / 2.85 million to the German benchmark of 210 t of HFCs. The result is the estimated HFC quantity used and emitted in a country in 2010.*

*Example Spain: 210 t x 2.22/2.85 = 163.6 t*

*Step 4: For the composition of this quantity, we also use the share of types of HFCs determined for Germany as a benchmark. The share of HFC-227ea in the total HFC quantity is estimated at ~ 7% (= 11.4 t). The remaining 152.2 t of HFCs are HFC-134a.”*

The factors applied for Hungary based on the above mentioned method:

Prevalence of asthma (and COPD) in HU : 4% (GINA report - please see references)

MDI share calculated as average of DE:50%; ES:80% = 65%

DE default (t/ million) : 210 t HFC / 2,85 million = 73.68 (to be multiplied with population, prevalence and MDI share)

HFC-134a / HFC-227ea share is : 0.93/ 0.07

In subsector Aerosols, annual sales data is directly reported by the producers.

#### **4.8.5.2 Recalculations, QA/QC activities, uncertainties and planned improvements**

The time series have been recalculated in 2014 submission in order to include emission from imported products. The method was recommended by the external expert during the “EU MS support Project” (described in chapter 4.8.2.3). Please find comparison table in chapter 10 of the NIR. The updated calculation is also reviewed by the expert of the MS Support Project and evaluated as good.

Further refinement of calculation method by application of country specific factors is possible

and further search for estimation method for the amount of import in products in the case of other, non-MDI aerosols too.

In addition we have got in touch with National Pharmaceutical Agency, so the verification or eventually direct application of data on amount of HFC-134a in pharmaceutical products might be possible in the future.

Uncertainties are estimated based on expert judgment in an aggregated way for all HFC emissions, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

Application of 2006 IPCC Guidelines is planned.

#### **4.8.6 Electrical Equipment (CRF sector 2.F.8)**

Emitted gases: SF<sub>6</sub>

##### **4.8.6.1 Methodological issues**

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. In sector 2.F.8. SF<sub>6</sub> emissions are calculated using the annual sales data reported by companies (T1 method). Manufacturing emissions are separated based on the data of a company reporting also manufacturing losses.

##### *Activity data*

Hungary imported 8.55 t SF<sub>6</sub> gas and exported 4.24 t within the field of electrical equipment in 2012. Data is collected from both manufacturers and the Hungarian Electrotechnical Association (MEE). The latter is appointed to data collection by 310/2008. Govt. Decree for data collection on import-export of SF<sub>6</sub>.

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 in 2011.

Trend of emissions in 2.F.8. subsector is included in Table 4.18.

##### *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.

##### **4.8.6.2 Recalculations, QA/QC activities, uncertainties and planned improvements**

In this year a mistype error in 2011 manufacturing losses data have been discovered and corrected. Please find the comparison table in chapter 10.

General QA/QC procedures apply.

Uncertainties are estimated based on expert judgment in an aggregated way for all SF<sub>6</sub> emissions, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

Change of calculation method to Tier 2 and review of activity data is planned as it will be compulsory for the application of 2006 IPCC Guidelines.

#### **4.8.7 Other applications (CRF sector 2.F.9)**

Emitted gases: SF<sub>6</sub>

##### **4.8.7.1 Methodological issues**

In subcategory 2.F.9 the emissions are 19% lower compare to last year. The actual emission of SF<sub>6</sub> in sector 2.F.9 is in direct correlation with the activity data. The activities reported in 2.F.9 are: sound-proof window production (only in the past due to the ban introduced by 842/2006/EC), scientific research and other non defined purposes.

The activity data for 2.F.9 is reported by one SF<sub>6</sub> wholesaler company, which reports the list of their customers too. The intended use of SF<sub>6</sub> is determined based on the sector of the activity of the customers. This year the company reported solely scientific research institutes and hospitals as customer, so the data has been assigned accordingly to 2.F.9. The activity data of 2.F.9 (and consequently the emissions calculated with present methodology too) show strong interannual variations throughout the whole time series.

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

##### *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 (only in the past), for leak testing, for researches or experiments. Information of traded gases was 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)

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

Trend of emissions in 2.F.9 subsector is included in Table 4.18.

##### **4.8.7.2 Recalculations, QA/QC activities, uncertainties and planned improvement**

There were no recalculations in this subsector in 2014 submission. General QA/QC procedures apply.

Uncertainties are estimated based on expert judgment in an aggregated way for all SF<sub>6</sub> emissions, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

Application of 2006 IPCC Guidelines is planned.

## 4.9 Other (CRF sector 2.G)

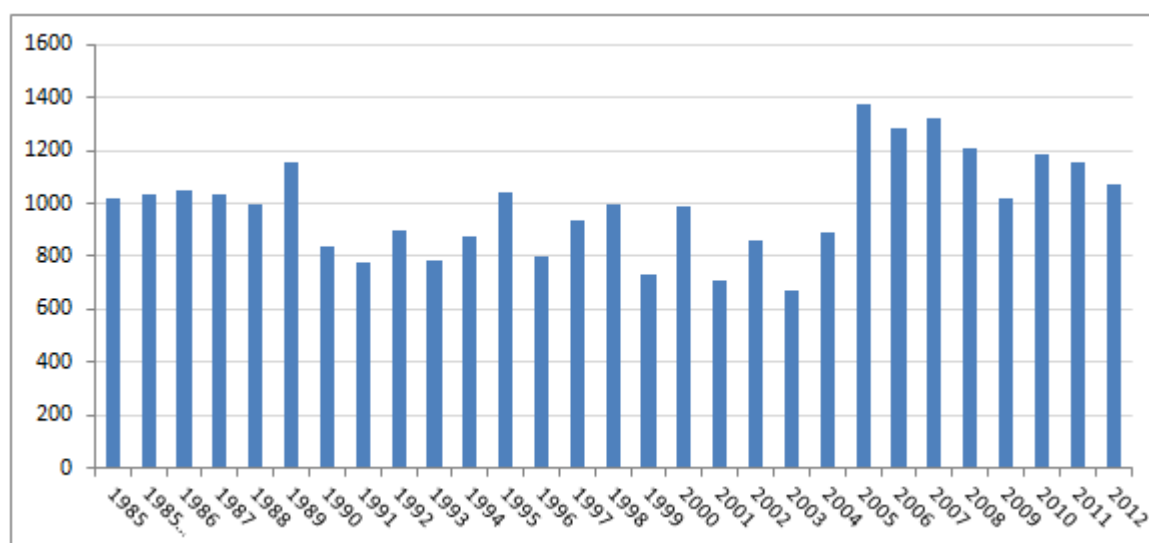
### 4.9.1.1 Source category description

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

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

### 4.9.1.2 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. In the case methane process emissions are significant, it is reported in the relevant industrial sector (e.g. 2.B.5 Chemical industry including carbon black and ethylene).



**Figure 4.19** Emission from feedstock and non-energy use of fuels (Gg CO<sub>2</sub>-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.

The issue of production of hydrogen in Hungary is still under investigation. Hydrogen production is present in the country using steam methane reforming (SMR, e.g. natural gas feedstock). However, the latest information received from the Hungarian Energy Office responsible for the compilation of IEA/EuroStat Energy statistics states that at the moment natural gas used for hydrogen production is reported as energy use in IEA Energy Statistics. So, at the moment emissions from hydrogen production are allocated in the GHG inventory accordingly (e.g. in sector 1A).

Natural gas used as a feedstock is reported presently in ammonia production (2.B.1) and Black carbon production (2.B.5). The remaining amount of natural gas used as NEU in the IEA Energy Statistics (5-7%) is accounted for in sector 2.G. The emission factors used in 2.G sector for Natural gas:

Carbon Emission Factor (t C/TJ) (IPCC1996 Energy Table 1.3): 15.3

Fraction of Carbon Stored (IPCC1996 Energy Table 1-5): 0.33

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.

Feedstock and non-energy use of fuels activity data time series have been recalculated based on IEA Energy Statistics and aggregated into 2.G.1.

Please note that emissions in 2.G. sector are calculated based on individual types of fuels and the default fraction of carbon stored from IPCC 1996 Energy Table 1-5. Therefore time series of emission does not follow the trend of the time series of SZUM TJ NEU and feedstock, but it depends on the contribution of the individual fuels of a given year. Not only the SZUM TJ data, but the contribution of the different fuels has been changed in IEA Energy Statistics compared to the old Hungarian Energy Statistics. This is why the difference between the new and old time series is not the same in CO<sub>2</sub> emissions than in SZUM TJ data. Please note that the significant interannual variations originate from the IEA Energy statistics data, as activity data.

In addition, verification was performed with EU ETS annual emission reports of Petrochemical companies as they are the users of several oil products for non-energy use. Based on EU ETS CO<sub>2</sub> emission data for naphta, LPG, Gas/Diesel Oil and Other Oil products, it was possible to express country specific C stored factors. So, these country specific values are also taken into consideration by the recalculation. The default and the county specific C stored values are presented in Table 3.1.4 in chapter 3.2.3 of the NIR.

#### **4.9.1.3 Source category description of recalculations, QA/QC activities, uncertainties**

Full time series have been recalculated due to update of IEA Energy Statistics and the result of the verification of C stored values. Please find the comparison table in chapter 10.

General QA/QC procedures apply. Cross checks with Energy sector and 2B Chemical Industry sector and verification of EU ETS data of petrochemical industries have been performed.

Resubmissions of the IEA Energy statistics (annual questionnaires) have been followed and the question regarding the issue of hydrogen production has been discussed with the Hungarian Energy Authority.

Uncertainties are estimated based on expert judgment, and the presently available values can be found in TableA7-1 in Annex 7 of the NIR.

#### **4.9.1.4 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 within the energy statistics, 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). The investigation advances slowly as a full review of NEU and feedstock category in the Energy Statistics is needed involving the institution responsible for compilation of the energy statistics.

Implementation of 2006 IPCC Guidelines will have significant effect in this sector too.

## 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), 2012: Statistical yearbook of Hungary (In Hungarian: Magyar statisztikai évkönyv, 2012), Budapest.

Hungarian Central Statistical Office (HCSO), Dissemination database, Industrial products  
<http://statinfo.ksh.hu/Statinfo/themeSelector.jsp?page=2&szst=OLD&lang=en>

EuroStat, PRODCOM database:

<http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction>

United Nations Statistics Division, UN List of Industrial Products:

<http://unstats.un.org/unsd/industry/commoditylist2.asp>

European Asphalt Pavement Association: Asphalt in Figure

[http://www.eapa.org/usr\\_img/Asphalt%20in%20figures%20Version%202022-12-2011.pdf](http://www.eapa.org/usr_img/Asphalt%20in%20figures%20Version%202022-12-2011.pdf)

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

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

IEA/EUROStat: Annual energy questionnaires, 2014 submission

[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)

601/2012/EC EU ETS Monitoring and Reporting Regulation

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

Preparatory study for the F-gas Review, Schwarz et al. (2011) Öko-Recherche GmbH) available at: [http://ec.europa.eu/clima/policies/f-gas/docs/2011\\_study\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_en.pdf)

UNEP – ECA Network meeting 2011, Budapest documents: <http://www.unep.org/ozonaction/ecanetwork/Activities2011/ThematicmeetinginBudapest/tabid/56112/Default.aspx>

Personal communication to Mr. Róbert Tóth (*Ministry for Environment, Nature and Water; HMS*), Mr. Attila Zoltán, Mrs. Erika Barna (*HMBC*)

## **2.F.2. Sector:**

DG Climate F-gases Regulation Review Study – SKM Enviros: Further Assessment of Policy Options for the Management and Destruction of Banks of ODS and F-Gases in the EU FINAL REPORT Revised Version 2 March 2012

[http://ec.europa.eu/clima/policies/ozone/research/docs/ods\\_f-gas\\_destruction\\_report\\_2012\\_en.pdf](http://ec.europa.eu/clima/policies/ozone/research/docs/ods_f-gas_destruction_report_2012_en.pdf)

IPCC/TEAP study – IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System Chapter 7 FOAM <http://www.ipcc.ch/pdf/special-reports/sroc/sroc07.pdf>

Emissions, Activity Data, and Emission Factors of Fluorinated Greenhouse Gases (F-Gases) in Germany 1995-2002 Adaptation to the Requirements of International Reporting and Implementation of Data into the Centralised System of Emissions (ZSE) by Dr. Winfried Schwarz Öko-Recherche Büro für Umweltforschung und –beratung GmbH, Frankfurt/Main <http://www.umweltdaten.de/publikationen/fpdf-l/2903.pdf>

Finnish 2002 Inventory of HFC, PFC and SF6 Emissions Teemu Oinonen, 2004 The Finnish Environment 686, Environmental Protection <http://www.ymparisto.fi/default.asp?contentid=73110&lan=en>

NL Agency - NL Energy and Climate - Secretary Team NBTM - Monitoring Protocols 12-022 HFCs from Other Use HFC <https://www.agentschapnl.nl/sites/default/files/12-022%20HFCs%20from%20Other%20Use.pdf>

PlasticsEurope - GUA - The potential of plastic insulation to realise energy savings and decoupling in Europe - Final report - January 2006 <http://www.plasticseurope.org/document/gua---the-potential-of-plastic-insulation-to-realise-energy-savings-and-de-coupling-in-europe---january-2006.aspx>

Helmut Winterling, Nathalie Sonntag: Polystyrene Rigid Foam (EPS, XPS) (Kunststoffe 10/2011) [http://www.plasticsportal.net/wa/plasticsEU~en\\_GB/function/conversions:publish/common/upload/technical\\_journals/plastics\\_trendreports/Rigid\\_polystyrene\\_foam.pdf](http://www.plasticsportal.net/wa/plasticsEU~en_GB/function/conversions:publish/common/upload/technical_journals/plastics_trendreports/Rigid_polystyrene_foam.pdf)

COM(2011) 581 final REPORT FROM THE COMMISSION On the application, effects and adequacy of the Regulation on certain fluorinated greenhouse gases (Regulation (EC) No 842/2006) [http://ec.europa.eu/clima/policies/f-gas/docs/report\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/docs/report_en.pdf)

Meeting Report of the Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs Petten, The Netherlands 26-28 May 1999 <http://www.unep.ch/ozone/Joint-IPCC-TEAP-HFC-PFC.shtml>

ISOPA- Socio- Economic Information on the European Polyurethanes Industry  
<http://www.isopa.org/isopa/uploads/Documents/documents/Soc-Econ%20Final%206-10-2003.pdf>

AFEAS (Alternative Fluorocarbons Environmental Acceptability Study), 1998: Production, Sales and Atmospheric Release of Fluorocarbons Through 1997. AFEAS, Washington, DC.

HFCs: A Critical Link in Protecting Climate and the Ozone Layer A UNEP Synthesis Report November 2011 [http://www.unep.org/dewa/Portals/67/pdf/HFC\\_report.pdf](http://www.unep.org/dewa/Portals/67/pdf/HFC_report.pdf)

Personal communication to Bodnár György (MEPS - Hungarian Association of EPS Insulating Foam Producers ) and Borzák Balarám Béla (building insulation architecture expert) and Buzási Vera (MMSZ – Hungarian Plastic Industry Association)

#### 2.F.4. method references

General info on medical aerosols: IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Climate System, 2005. Chapter 8: Medical Aerosols.

Prevalence of asthma: Global Initiative for Asthma (GINA) (Publication: Global Burden of Asthma, Authors: Matthew Masoli, Denise Fabian, Shaun Holt, Richard Beasley (Medical Research Institute of New Zealand, Wellington, New Zealand; University of Southampton, Southampton, United Kingdom), 2004.

German data (for benchmark): The time series has been published until 2008 so far: <http://www.umweltdaten.de/publikationen/fpdf-l/3999.pdf> (page 37)

Approach: Schwarz, W.; Gschrey, B.; Leisewitz, A.; Herold, A.; Gores, S.; Papst, I.; Usinger, J.; Oppelt, D.; Croiset, I.; Pedersen, P.H.; Colbourne, D.; Kauffeld, M.; Kaar, K.; Lindborg, A.: Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases. September 2011. The approach is described in the Annex volume (p.142): [http://ec.europa.eu/clima/policies/f-gas/docs/2011\\_study\\_annex\\_en.pdf](http://ec.europa.eu/clima/policies/f-gas/docs/2011_study_annex_en.pdf)

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

### Major changes compared to previous submission:

- NMVOC emissions in sector 3 are now consistent with CLRTAP reporting, therefore CO<sub>2</sub> emissions from the oxidation of NMVOC have been changed;
- Time series of 3.D.5 whipped cream subsector includes now import in products too.

### 5.1 Overview of the sector

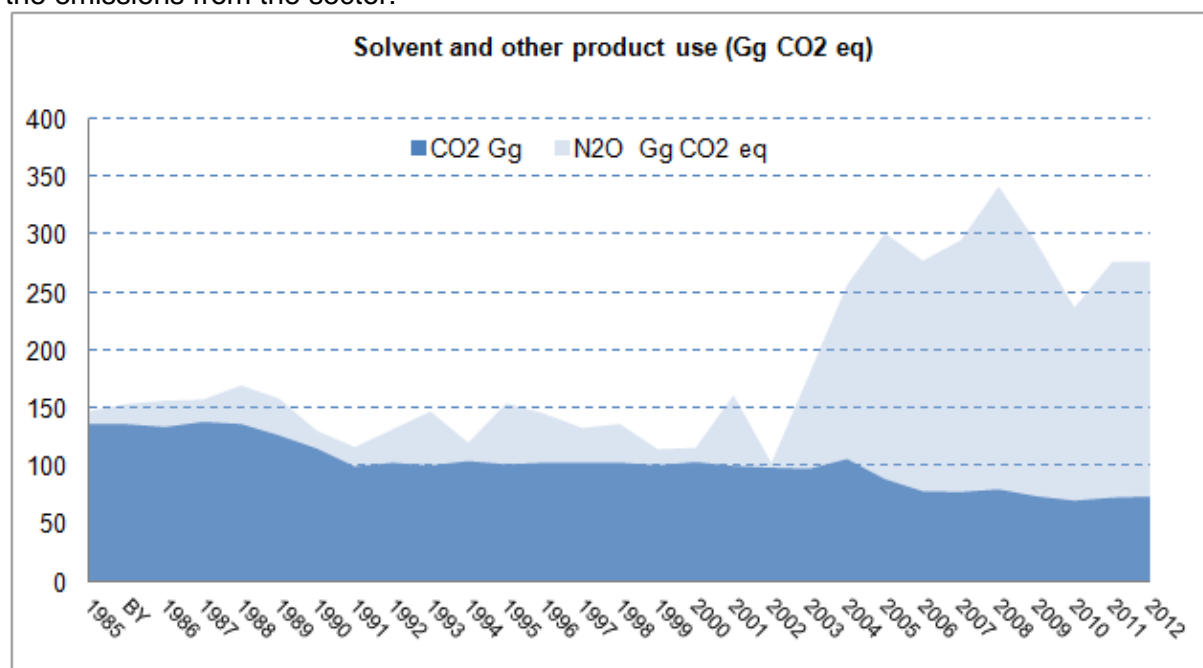
#### 5.1.1.1 Source category description

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

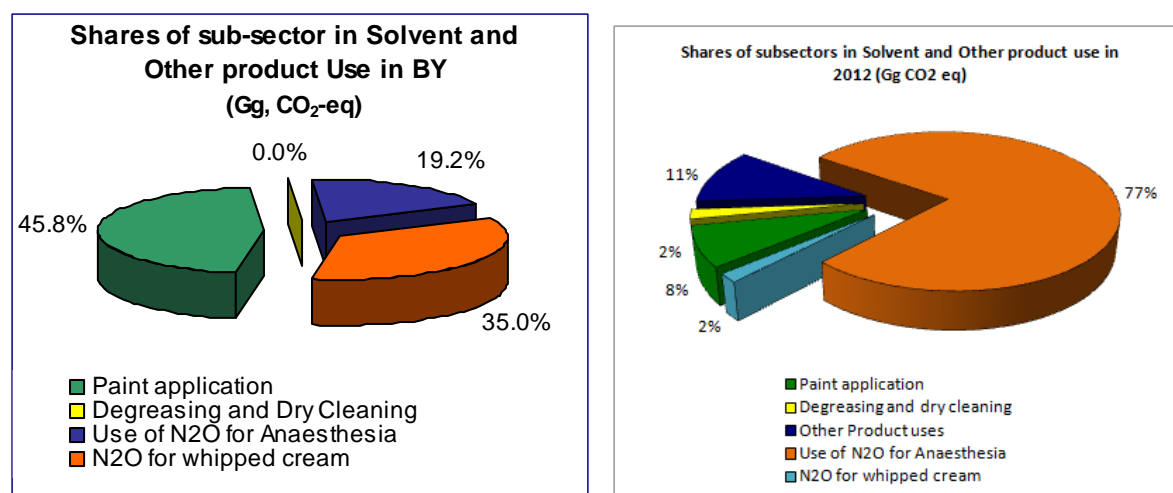
#### 5.1.1.2 Methodological issues

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 (1985-2012)

In 2012 this category had a contribution of 0.6% (excluding LULUCF) to total greenhouse gas emissions (350.5Gg CO<sub>2</sub> equivalents). There has been an increase of 20.9% from base year to 2012 and increase of 0.3% between 2011 and 2012.



**Figure 5.2** Shares of sub-sectors in Solvent sector, in base year and 2012 (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 2012, use of N<sub>2</sub>O for anaesthesia sub-sector accounted for 77%, followed by paint application 8%.

## 5.2 Paint, Solvent and Other Product Uses (CRF Sector 3.A, 3.B, 3.C )

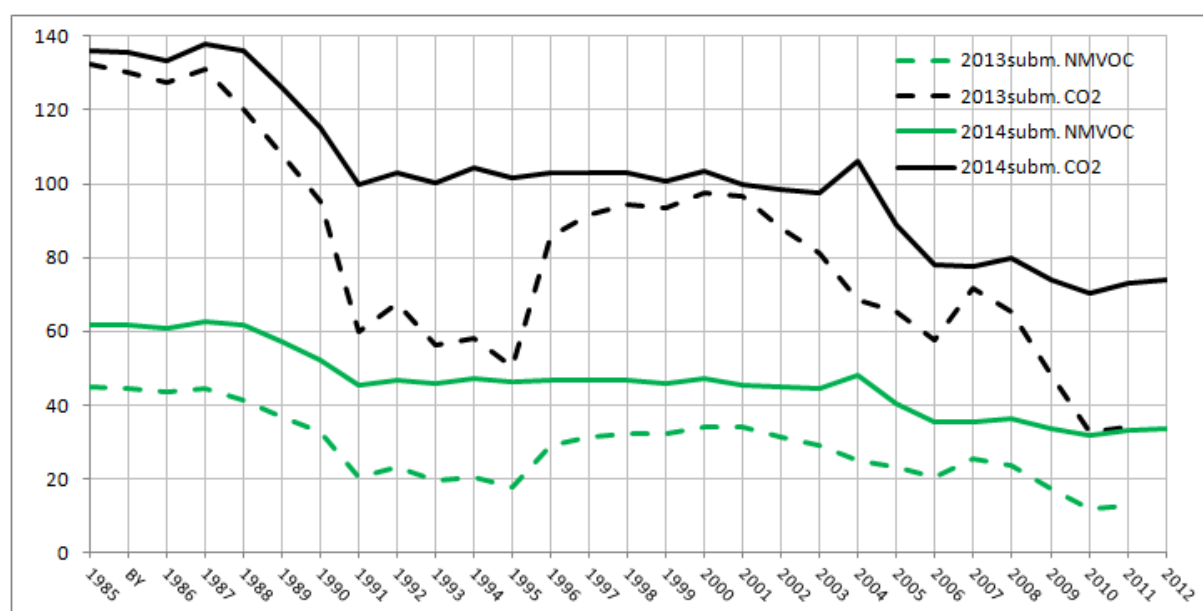
### 5.2.1.1 Source category description

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.

### 5.2.1.2 Methodological issues

In 2014 submission, NMVOC emissions in CRF sector 3 are fully consistent with NMVOC emission in NFR sector 3 of CLRTAP (Convention on Long-range Transboundary Air Pollution) reporting. However please note that NMVOC emissions from NFR sector 3C and 3D are aggregated and reported here in CRF sector 3C, because in CRF sector 3D is for reporting of N<sub>2</sub>O use.

As the note of CRF Table 3 states, in sector 3 "The quantity of carbon released in the form of NMVOCs should be accounted for in both the NMVOC and the CO<sub>2</sub>". Therefore the recalculation of NMVOC time series within this sector caused recalculation of CO<sub>2</sub> time series too. 2.2 g CO<sub>2</sub> /g NMVOC default IPCC2006 factor is used for the calculation of CO<sub>2</sub> emission in all the subsectors.



**Figure 5.3** Gg NMVOC and CO<sub>2</sub> emissions from sectors 3

Emission in 3.A Paint subsector are calculated using Paint consumption (import-export+production) and 250 g NMVOC / kg paint emission factor consistent with CLRTAP reporting.

**Table 5.1** NMVOC and CO<sub>2</sub> emissions 3A,3B and 3C sectors

	3 A 1		SZUM 3.B.1-2		CRF 3.C = SZUM NFR 3.C+ 3.D.	
	NMVOC	CO <sub>2</sub>	NMVOC	CO <sub>2</sub>	NMVOC	CO <sub>2</sub>
BY	40.65	<b>89.42</b>	3.19	<b>7.02</b>	17.87	<b>39.30</b>
1990	32.02	<b>70.43</b>	3.15	<b>6.93</b>	17.10	<b>37.62</b>
1995	26.19	<b>57.61</b>	3.14	<b>6.90</b>	16.80	<b>36.96</b>
2000	26.82	<b>59.00</b>	3.09	<b>6.79</b>	17.10	<b>37.62</b>
2005	14.77	<b>32.50</b>	3.11	<b>6.83</b>	22.44	<b>49.37</b>
2006	13.02	<b>28.64</b>	3.11	<b>6.84</b>	19.44	<b>42.76</b>
2007	14.46	<b>31.81</b>	3.11	<b>6.85</b>	17.78	<b>39.12</b>
2008	15.83	<b>34.82</b>	3.07	<b>6.76</b>	17.45	<b>38.38</b>
2009	12.15	<b>26.73</b>	3.05	<b>6.70</b>	18.47	<b>40.63</b>
2010	11.31	<b>24.89</b>	3.05	<b>6.71</b>	17.62	<b>38.77</b>
2011	12.14	<b>26.71</b>	3.04	<b>6.70</b>	17.95	<b>39.49</b>
2012	12.83	<b>28.22</b>	3.06	<b>6.73</b>	17.67	<b>38.87</b>

Time series of 3.B – Dry cleaning and degreasing are also calculated using EMEP/EEA 2009 default EF for NMVOC inhabitant/year of the country as activity data.

Sector 3.C includes NMVOC emission from NFR 3.C Chemical products use, NFR 3.D.1 Printing, NFR 3.D.2. Domestic solvent use, and NFR 3.D.3. Other product uses (Tobacco consumption). Default EMEP/EEA 2009. EFs and statistics from HCSO are used in all subsectors. The calculation method of the NMVOC emissions is described in detail in Informative Inventory Report of Hungary submitted for CLRTAP reporting, available at: [http://www.ceip.at/ms/ceip\\_home1/ceip\\_home/status\\_reporting/2014\\_submissions/](http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2014_submissions/)

### 5.2.1.3 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.

The statement above and the old uncertainty values are applied in 2014 submission as well. In 2014 submission NMVOC emissions are calculated consistent with reporting under Convention on Long-range Transboundary Air Pollution. Please find the presently available uncertainty values based on expert judgment in Table A7-1 in Annex 7 of the NIR.

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

No sector specific information is available.

### 5.2.1.5 Source-specific recalculations

Recalculation of time series are due to reporting of NMVOC emissions consistent with reporting under Convention on Long-range Transboundary Air Pollution. Please find comparison table in chapter 10.3 of the NIR.

### 5.2.1.6 Source-specific planned improvements

Follow-up of the recalculations of time series in CLRTAP reporting due to application of EMEP/EEA 2013 Guidebook is needed.

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

Emitted gas: N<sub>2</sub>O

Key source: N<sub>2</sub>O in Level and Trend in Tier1 analysis

### 5.3.1.1 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).

### 5.3.1.2 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 (1985-2012, 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	2002
Anaesthesia	0.309	0.252	0.354	0.333	0.299	0.328	0.275	0.304	0.459	0.275
Cartridge	0.167	0.137	0.145	0.137	0.131	0.113	0.096	0.071	0.061	0.057

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Anaesthesia</b>	0.533	0.790	0.932	0.864	0.927	1.077	0.923	0.743	0.869	0.872
<b>Cartridge</b>	0.046	0.039	0.039	0.030	0.025	0.025	0.021	0.021	0.023	0.020

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.

In 2014 submission an expert from the manufacturer of whipped cream chargers (cartridges) containing N<sub>2</sub>O provided an estimate for the share of imported products on the Hungarian market as well. In 2014 submission this amount has been included in the time series. Please find the comparison table in chapter 10.3 of the NIR.

N<sub>2</sub>O emission reported in sector anaesthesia is calculated based on the direct reporting of the N<sub>2</sub>O producer company. So, in fact is assumed that all N<sub>2</sub>O except for the use for whipped cream is used for anaesthesia. The delivery for domestic consumption of the Hungarian producer and manufacturing losses are taken into account as emission.

The strong interannual variations are due to the interannual variations of the reported data, which is related to the production of the company and the volatility of the market. It was a planned improvement and recommendations of previous reviews to search for data on import in products and the investigation is still on-going. At the moment it seems very probable that there is no notable import as the Hungarian producer is the most important producer of the whole region. In addition the wholesalers having a valid wholesaling authorisation for products containing nitrous-oxide issued by the National Institute of Pharmacy (the agency responsible for licensing and control of drugs) have been identified. Most of them have already declared that they acquire N<sub>2</sub>O domestically (from the Hungarian producer).

#### 5.3.1.3 Uncertainties and time series consistency

Production data are highly reliable because they are obtained directly from manufacturers. Please find the presently available uncertainty values based on expert judgment in TableA7-1 in Annex 7 of the NIR.

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

No sector specific information is available.

#### 5.3.1.5 Source-specific recalculation

Please find comparison table in chapter 10.3 of the NIR.

#### 5.3.1.6 Source-specific planned improvements

Further investigation of data regarding imported products and the review and analysis of the data provided by the producer companies is also needed in addition to the application of 2006 IPCC Guidelines

## 6. AGRICULTURE (CRF sector 4)

### 6.1 Overview of sector

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

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

Category 4.E Prescribed Burning of Savannas is not relevant to Hungary therefore notation keys 'NO' is used in relation to all associated emissions in the CRF Tables. Following a potential recommendation from the annual review conducted in 2013, the NIR has been supplemented with a new chapter on 4.E for this submission.

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).

For this inventory submission significant developments were implemented in the Agricultural inventory following the undermentioned recommendations of the EU and UNFCCC reviews.

The 2012 EU technical review revealed that the CH<sub>4</sub> emissions from 4.A Enteric Fermentation in Cattle were overestimated in the Hungarian inventory. The centralized reviews conducted in 2011 and 2012 also indicated that the estimate of average gross energy intake for dairy cattle is the highest among all reporting Parties, thus to report additional information on feed energy conversion was recommended. To clarify these outstanding issues a research project was initiated by the HMS in 2012 to get reliable data on body mass, digestible energy intake and gross energy intake for Cattle. The new research project also aimed the revision of the N-excretion rate for Cattle and Swine and volatile solid excretion rate for Poultry, because the last two issues were also subjects of former recommendations of the annual reviews.

The research project had finished in 2013 and the new results were taken into account in this submission for the first time.

In line with the potential recommendations of the previous annual review the following actions have been taken for this submission:

- Corrections have been done in the CRF Tables;
- Supplementary information on CRF sectors 4.A, 4.B, 4.D and 4.F have been provided in the NIR;
- Country-specific values of methane conversion rate have been developed for the estimation of CH<sub>4</sub> emissions from enteric fermentation in cattle based on the new research results.

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 3.2 per cent in 2012 (HCSO, 2013). The agricultural land area was 57 per cent of the total (HCSO, 2013).

According to the data of the General Agricultural Census, 2010 (HCSO, 2011b), 8606 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 2188 agricultural enterprises and 379 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 per cent of sheep population is owned by them. The agricultural enterprises and private farms play approximately an equivalent role relating to poultry farming.

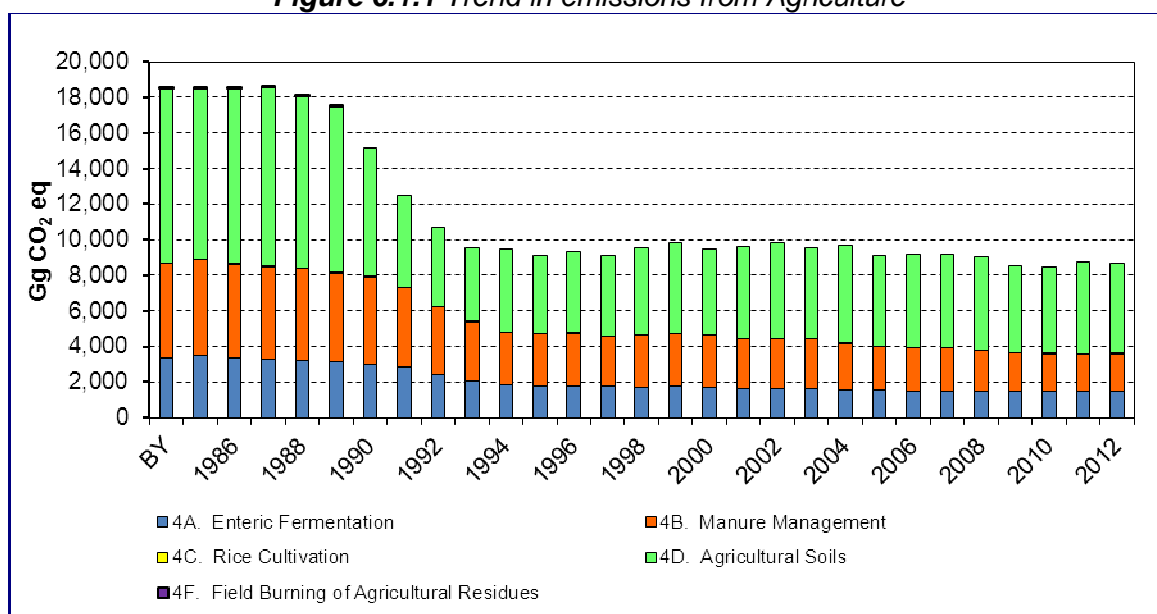
The main characteristics for trends are as follows:

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 per cent 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 per cent 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 2012, the agriculture sector contributed 14.0% of Hungary's total GHG emissions (excluding LULUCF). The trend in emissions (Figure 6.1.1) shows a decrease of 53% over the period of 1985-2012 as a result of a drop in activity data. The contribution of agriculture to total emissions decreased from 16.2% to its present share of 14.0% in the years 1985-2012. The bulk of this decline occurred between 1985 and 1995, when agricultural production fell by more than 30 per cent, and livestock numbers underwent a drastic decrease. Between 1996 and 2008, agricultural emissions are relatively constant around 9.4 Mt with fluctuations up to 4%, and decreased by 11 per cent reaching the all-time low level in 2010. There was a slight increase in emissions in 2011 which reflect the slight increase in fertilizer use. In 2012 emissions remained almost unchanged compared to the previous year, because the slightly higher emissions due to the increasing fertilizer use and cattle livestock population were nearly compensated by the effects of decreasing swine and poultry livestock number and lower amount of harvested crops.

Addressing a question raised by the ERT during the centralized review conducted in 2013 it should be noted that in the Hungarian CRF Reporter Program the BY is between the years of 1985 and 1986 in contrast to the Excel sheets generated from the CRF Reporter Programs, in which the BY precedes the year of 1985. Thus, to avoid confusions in the Tables of the NIR the source data for the CRF Reporter Program are ranked in order of the CRF Reporter Program, while data taken from the CRF Excel, e.g. trends, are provided in the order of the CRF Excel sheets.

**Figure 6.1.1** Trend in emissions from Agriculture

#### 6.1.1.1 Emission trends per gas

From 1985 to 2012 CH<sub>4</sub> and N<sub>2</sub>O emissions from agriculture have been decreased by 59 and 50%, respectively.

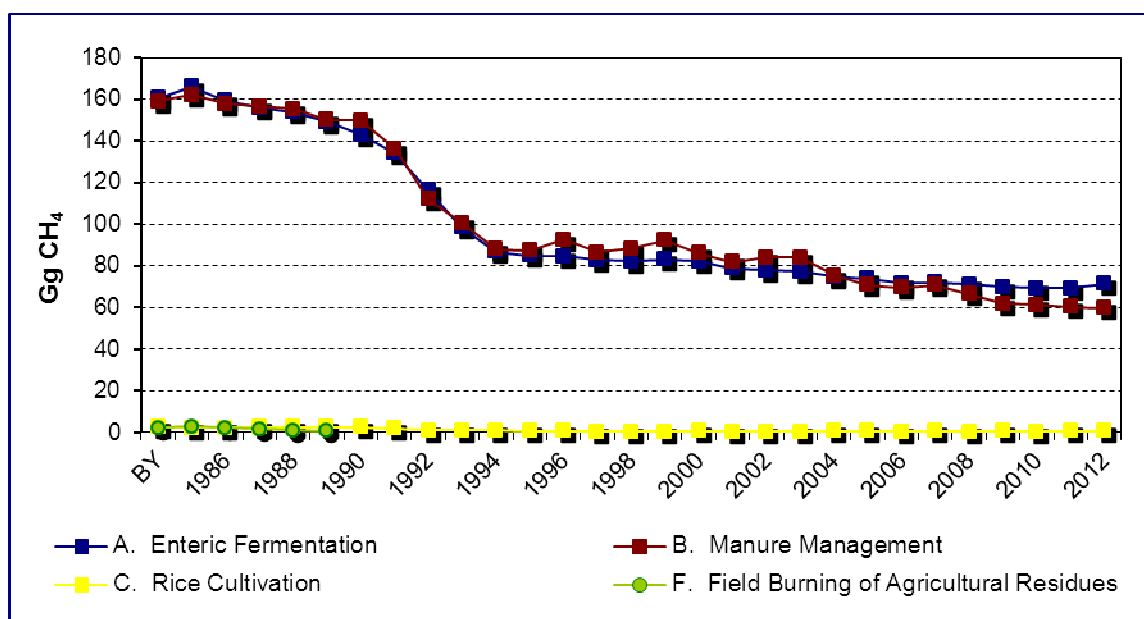
The trends by gas are presented in Table 6.1.1, Figure 6.1.2 and Figure 6.1.3.

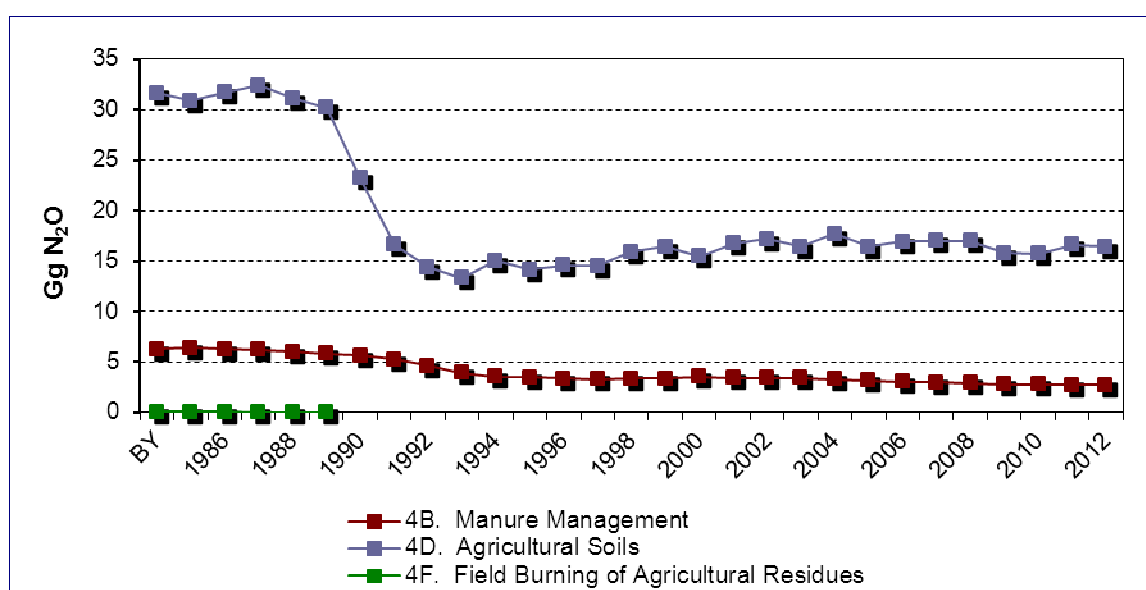
**Table 6.1.1** Emissions of CH<sub>4</sub> and N<sub>2</sub>O from Agriculture 1985-2012

Year	GHG emissions (Gg)	
	CH <sub>4</sub>	N <sub>2</sub> O
BY	324	38
1985	333	37
1986	321	38
1987	317	39
1988	313	37
1989	302	36
1990	295	29
1991	272	22
1992	229	19
1993	200	17
1994	176	19
1995	173	18
1996	178	18
1997	170	18
1998	171	19
1999	176	20
2000	169	19
2001	161	20
2002	162	21
2003	162	20
2004	151	21
2005	145	20
2006	142	20

Year	GHG emissions (Gg)	
	CH <sub>4</sub>	N <sub>2</sub> O
2007	143	20
2008	138	20
2009	132	19
2010	131	19
2011	130	19
2012	132	19
Share in Hungarian total in BY	4%	9%
Share in Hungarian total in 2012	4%	7%
Trend BY-2012 (%)	59	50

**Figure 6.1.2** CH<sub>4</sub> emissions from Agriculture 1985-2012



**Figure 6.1.3**  $N_2O$  emissions from Agriculture 1985-2012

#### 6.1.1.2 Emission trends per subcategory

Table 6.1.2 shows 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 8.2%, followed by 4.B Manure management at 3.4%, and 4.A Enteric Fermentation at 2.4%, 4.C Rice Cultivation accounts for less than one-tenth of a per cent of the national total.

GHG emissions amounted to 18,588 Gg CO<sub>2</sub>-eq in the BY and 8,705 Gg CO<sub>2</sub>-eq in 2012, which means a reduction of 53%. 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 9.4 million tones, which is about 50% of the base year level. 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 the period between 2010 and 2012 the use of synthetic fertilizer slightly had increased. In 2010 this growing emissions was eliminated by the lower emissions from crop residues resulting in the lowest level in the whole time-series. In 2011 the crop production increased leading to increasing agricultural emissions, although emissions from animal husbandry slightly reduced in that year, reflecting the moderately decreasing livestock number of cattle, swine, sheep and poultry (Table 6.2.1). However, this reduction could not counterbalance the higher emission level from crop production resulting in slightly higher overall emissions from the sector comparing to the one year before.

In 2012 emissions remained almost unchanged compared to the previous year, because the slightly higher emissions due to the increase in the fertilizer use and cattle livestock population were nearly compensated by the effects of decreasing swine and poultry livestock

number and lower amount of harvested crops.

Unfortunately, in the 2013 submission of the NIR there was a sign mismatch concerning the 4.F in the Table 6.1.2 resulting in a potential recommendation from the latest UNFCCC review. For this submission the error has been corrected and NA is shown in Table 6.1.2 in line with the recommendation.

**Table 6.1.2 GHG emissions 1985-2012 from agriculture by subcategories**

Year	GHG emissions (Gg CO <sub>2</sub> -eq)					
	4	4.A	4.B	4.C	4.D	4.F
BY	18,588	3,369	5,288	51	9,822	59
1985	18,580	3,488	5,387	47	9,583	75
1986	18,538	3,344	5,255	49	9,834	56
1987	18,647	3,275	5,222	55	10,049	45
1988	18,105	3,228	5,133	55	9,659	29
1989	17,517	3,131	4,965	50	9,355	15
1990	15,159	3,006	4,898	50	7,205	NO
1991	12,502	2,815	4,491	38	5,159	NO
1992	10,711	2,441	3,781	21	4,467	NO
1993	9,543	2,065	3,327	21	4,130	NO
1994	9,457	1,822	2,949	21	4,665	NO
1995	9,106	1,780	2,926	17	4,383	NO
1996	9,295	1,778	2,979	13	4,525	NO
1997	9,088	1,736	2,843	9	4,500	NO
1998	9,569	1,726	2,906	10	4,927	NO
1999	9,836	1,746	2,991	9	5,089	NO
2000	9,452	1,722	2,909	14	4,808	NO
2001	9,647	1,655	2,788	10	5,194	NO
2002	9,800	1,635	2,823	9	5,332	NO
2003	9,531	1,619	2,816	11	5,086	NO
2004	9,681	1,573	2,603	12	5,493	NO
2005	9,132	1,552	2,472	11	5,097	NO
2006	9,167	1,508	2,403	10	5,246	NO
2007	9,206	1,511	2,410	11	5,275	NO
2008	9,069	1,491	2,294	11	5,273	NO
2009	8,539	1,469	2,167	11	4,891	NO
2010	8,498	1,454	2,148	8	4,887	NO
2011	8,730	1,453	2,118	11	5,147	NO
2012	8,705	1,502	2,104	12	5,087	NO
Share in Hungarian total in BY	16.2%	2.9%	4.6%	0.04%	8.6%	0.1%
Share in Hungarian total, in 2012	14.0%	2.4%	3.4%	0.02%	8.2%	NA
Trend BY-2012	-53%	-55%	-60%	-75%	-48%	NA

### 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 the 2006 IPCC Guidelines was applied.

IPCC Tier 2 method was used for the following categories: 4A Enteric Fermentation in Cattle, 4B Manure Management (CH<sub>4</sub>) associated with all livestock categories, except Rabbits. For other categories IPCC Tier 1 methods were applied. Country-specific emission 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.

As part of our development projects for the 2013 submission, the uncertainty estimation for the Agriculture sector was improved by introducing the Tier 2, Monte-Carlo approach. The simulation was carried out by using a VBA (Visual Basic for Application) Excel macro implemented by the agricultural expert of the HMS's GHG Division. The VBA macro uses iteratively the calculation sheets for the estimation of agricultural emissions. The simulation was run with 10,000 steps.

Uncertainty estimates were performed separately, using the Tier 1 approach based on the error propagation, as well as the Tier 2, Monte-Carlo approach. Comparison of the results of the two approaches ensured the quality check of the uncertainty estimations. The average of the randomly simulated emissions by Monte-Carlo-simulation was also compared with the results in the total agricultural emissions as an additional quality check. More details relating to the results of the Monte Carlo-simulation is available in a special report.

Error propagation was calculated independently for the lower (2.5 percentile) and for the upper (97.5 percentile) range to treat the asymmetric confidence ranges. Uncertainties were combined in accordance with GPG (IPCC, 2000) Equation 6.3 and 6.4. The results of the Tier 1 approach are shown in Table 6.1.4.

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) and the Guidelines (IPCC, 2006) recommendations. The uncertainty of the livestock population data for 2012 is presented according to the uncertainty assessment of the HCSO, in Table 6.1.3. The overall weighted mean of the uncertainties in the livestock population is  $\pm 1.4$  per cent. The uncertainty in the swine population is the lowest (0.9 per cent), while the uncertainty in the mules and asses population is the highest (greater than 11 per cent). The overall uncertainties of the activity data, emission factors and emissions by subcategories are summarized in Table 6.1.4 and 6.1.5. For more details of the uncertainty assessment see the subsector chapters.

In the Hungarian agricultural GHG inventory, the uncertainties of N<sub>2</sub>O emissions from agricultural soils are the highest. These high values derive from the uncertainties of the emission factors. The uncertainty and the distribution of these emission factors (EF<sub>1</sub>, EF<sub>4</sub> and EF<sub>5</sub>) strongly influence the uncertainty and the distribution of the agricultural emissions as

well as the overall uncertainty of the Hungarian GHG inventory. For these emission factors default confidence limit ranges and lognormal distributions have been applied according to the GPG (IPCC, 2000).

The Tier 2 uncertainties were calculated based on the 2013 submission. These values depend mainly on the uncertainty of the emission factors, which do not change significantly year by year. Thus, the annual update of this uncertainty assessment seemed to be unnecessary despite the revisions.

**Table 6.1.3 Uncertainty of animal population data for 2012 (HCSO)**

Livestock categories	2011 Dec	2012 Jun	2012 Dec	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	11.00	11.60	11.50	7.03	2.76	255
Non-Dairy Cattle	15.00	16.70	18.00	10.20	2.16	473
Buffalo	0.04	0.60	0.40	0.32	9.44	3
Sheep	94.60	95.70	100.30	58.97	5.17	1141
Goats	6.20	8.10	6.90	4.67	5.42	86
Horses	4.60	4.80	4.80	2.92	3.84	76
Mules and Asses	0.61	0.61	0.71	0.38	10.80	4
Swine	46.70	43.60	44.10	27.08	0.92	2952
Poultry	928.89	926.99	1,042.26	580.22	1.35	42908
Rabbit	23.00	27.40	22.90	15.92	1.49	1070
Overall (weighted mean)					1.4	

**Table 6.1.4 Uncertainties of activity data, emission factors and emissions for key categories by Tier 1 approach**

4. Agriculture	GHG	Uncertainty of activity data	Uncertainty of Emission Factor	Combined uncertainty of emissions
		%		
4.A.1 Enteric Fermentation/ Cattle	CH <sub>4</sub>	±3	±20	±20
4.B.1 Manure Management/ Cattle	CH <sub>4</sub>	±3	±30	±30
4.B.8 Manure Management/Swine	CH <sub>4</sub>	±1	±30	±30
4.B.13 Manure Management/ Solid	N <sub>2</sub> O	±35	-50/+100	-61/+106
4.B Manure Management/ Other	N <sub>2</sub> O	±56	-50/+100	-75/+114
4.D.1 Direct Soil Emissions	N <sub>2</sub> O	±33	-80/+380	-87/+381
4.D.2 Pasture, Range and Paddock Manure	N <sub>2</sub> O	±19	-50/+100	-53/+102
4.D.3 Indirect Emissions	N <sub>2</sub> O	±36	-80/+100 -92/+380	-98/+354

**Table 6.1.5** *Uncertainties and distributions of emission factors and emissions for key categories by Tier 2 approach (based on the 2013 submission)*

4 Agriculture	GHG	Emission factor		Combined uncertainty of emissions
		Uncertainty	Distribution	
4.A.1 Enteric Fermentation/ Cattle	CH <sub>4</sub>	±20	Normal	±14
4.B.1 Manure Management/ Cattle	CH <sub>4</sub>	±30	Normal	±21
4.B.8 Manure Management/Swine	CH <sub>4</sub>	±30	Normal	±29
4.B.13 Manure Management/ Solid	N <sub>2</sub> O	-50/+100	Lognormal	-55/+92
4.B Manure Management/ Other	N <sub>2</sub> O	-50/+100	Lognormal	-51/+86
4.D.1 Direct Soil Emissions	N <sub>2</sub> O	-80 / +380	Lognormal	-84/+279
4.D.2 Pasture, Range and Paddock Manure	N <sub>2</sub> O	-50/+100	Lognormal	-56/+95
4.D.3 Indirect Emissions	N <sub>2</sub> O	-80 / +100	Lognormal	-86/+345
		-92 / +380		

### 6.1.5 Quality Assurance and Quality Control

The agricultural greenhouse gas inventory is compiled by the HMS. The used activity data are mainly derived from the official database of the HCSO, in cases where HCSO's data are not available the EUROSTAT's or the Research Institute for Agricultural Economics' data are applied.

Data and documentation are archived by the Hungarian Meteorological Service Greenhouse Gas Division. 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;
- Verification of activity data with other data sources if it is possible;
- 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 (especially EU's member states) according to the EU's NIR and S&A report of the UNFCCC;
- Check of the methodologies used for the development of county-specific emission factors, comparison with the IPCC methodologies or other methodologies if it is available;
- 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.
- Listing of QA/QC findings and the actions taken in the spreadsheets;
- Recording of sources of activity data and equations in the spreadsheets;

As a new element in the agricultural sector specific QA/QC procedure, since 2014 we have started to compare the resulted emissions with the FAO's GHG-databases and recording the reasons for the difference.

Details of other source-specific quality checks can be found in the respective sub-chapters.

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 provides an additional opportunity to cross-check the activity data and emissions with the GHG-inventory to ensure the consistency between the two inventories.

Hungary as a member state of the EU has additional reporting obligations arising from different Community policies. In some cases, the same data and coefficients are required for the background calculation of these reports. As an additional QA procedure, these data and methodologies are compared in the course of regular expert meetings.

Checks and reviews performed by the EU are also considered as a quality assurance activities, for example the completeness check after 15th January submission.

In addition, in-depth reviews required by the 406/2009/EC EU Effort Sharing Decision are performed in every two years by external experts contracted by the EU, which covers the full inventory. First review was performed in 2012. The findings of the review were also taken into account in the Development Plans.

External co-expert opinion was prepared on the entire inventory, so also on the Agriculture chapter in 2007 (Systemexpert 2007).

### **6.1.6 Recalculations**

Recalculations in the Agriculture sector were made in order to adapt the results of a research project finished in 2013. The subjects of the project were assigned in line with the findings of the EU technical review and the UNFCCC annual reviews, namely to get more reliable data on gross energy intake and N-excretion rate for Cattle and Swine and volatile solid excretion rate for Poultry. Replacing these values in the inventory by the new research outcomes resulted in recalculations in the full time-series throughout the agricultural inventory, because the revision affected the emissions from 4.A Enteric Fermentation and 4.B Manure Management as well as the 4.D Agriculture Soils as a consequence of the changes in the annual amount of animal manure nitrogen applied to soils and the N excreted on pasture.

The other significant changes resulting in recalculations are the revision of crop residue parameters as a result of the QA/QC procedures. In the course of the annual QC procedure the source of the applied parameters were examined to fulfill the ERT recommendation to include this information in the NIR. During the process it was revealed that in some cases, mostly, when default values were not provided in the IPCC Guidelines, estimated values were applied which could have been replaced by more reliable values taken from the literature or results of laboratory measurements. Now, these values were revised for the CRF sectors 4.D.1.3 and 4.D.1.4.

For the year of 2011 the chronological mean of the guinea-fowl livestock population was also corrected because of a former calculation error, which resulted in an increase in the poultry livestock population for that year.

Although the revisions affected important values in the inventory, the overall impact of these recalculations on the Agriculture sector were not significant. The decrease of total GHG-emissions is in the range 0.3 to 2.9% (Table 6.1.6). The effect is slightly more significant when looking at the CH<sub>4</sub> emissions separately where the percentage decrease ranged from 3.0 to 6.8 per cent, while the N<sub>2</sub>O emissions decreased at the beginning of the inventory period as well as for the BY and increased in a small extent for the other years, ranging from 0.1 to 1.8 per cent for the years between 1988 and 2011.

The reasons for the rising N<sub>2</sub>O emissions are that the revised N excretion for Swine as well as the revision of the crop residue parameters resulted in slightly higher emissions of this gas. While the cause of the decreasing CH<sub>4</sub> emissions are the lower emissions from Cattle. The recalculations by source categories are as follows:

#### 4.A Enteric Fermentation

- Revision of gross energy intake and methane conversion rate for Cattle for the full time-series;
- Revision of Poultry livestock population for the year 2011.

#### 4.B Manure Management CH<sub>4</sub>

- Revision of volatile solid excretion rate for Cattle and Poultry for the full time-series;
- Revision of Poultry livestock population for the year 2011.

#### 4.B Manure Management N<sub>2</sub>O

- Revision of N excretion rate of Cattle and Swine for the full time-series;
- Revision of Poultry livestock population for the year 2011.

#### 4.D Agricultural Soils

##### 4.D.1 Direct Soil Emissions

##### 4.D.1.2 Animal Manure Applied to Soils

- Revision of annual amount of animal manure nitrogen applied to soils for the full time-series;

##### 4.D.1.3 N-fixing Crops

- Revision of crop residue parameters for the full time-series;

##### 4.D.1.4 Crop Residue

- Revision of crop residue parameters for the full time-series;

##### 4.D.2 Pasture Range and Paddock Manure

- Revision of annual amount of animal manure nitrogen applied to soils for the full time-series as a result of the change in the N-excretion of Cattle and Swine;

##### 4.D.3 Indirect Emissions

##### 4.D.3.1 Atmospheric Deposition

- Revision of the volatilized N from animal manure for the full time-series as a result of the change in the N-excretion of Cattle and Swine;

##### 4.D.3.2 Nitrogen Leaching and Run-off

- Revision of the volatilized N from animal manure for the full time-series as a result of the change in the N-excretion of Cattle and Swine.

**Table 6.1.6** *The net changes in the emissions due to recalculations in the 4.Agriculture sector*

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
BY	19,044	18,588	-456	-2.4%
1985	19,064	18,580	-485	-2.5%
1986	18,988	18,538	-450	-2.4%
1987	19,079	18,647	-432	-2.3%
1988	18,499	18,105	-394	-2.1%
1989	17,876	17,517	-359	-2.0%
1990	15,477	15,159	-318	-2.1%
1991	12,864	12,502	-361	-2.8%
1992	11,028	10,711	-317	-2.9%
1993	9,824	9,543	-280	-2.9%
1994	9,711	9,457	-254	-2.6%
1995	9,296	9,106	-190	-2.0%
1996	9,458	9,295	-162	-1.7%
1997	9,189	9,088	-101	-1.1%
1998	9,658	9,569	-89	-0.9%
1999	9,927	9,836	-91	-0.9%
2000	9,534	9,452	-81	-0.9%
2001	9,731	9,647	-84	-0.9%
2002	9,875	9,800	-75	-0.8%
2003	9,611	9,531	-80	-0.8%
2004	9,769	9,681	-88	-0.9%
2005	9,196	9,132	-64	-0.7%
2006	9,210	9,167	-43	-0.5%
2007	9,237	9,206	-30	-0.3%
2008	9,113	9,069	-45	-0.5%
2009	8,578	8,539	-39	-0.5%
2010	8,531	8,498	-33	-0.4%
2011	8,759	8,730	-29	-0.3%

**Table 6.1.7** *Changes in the CH<sub>4</sub> emissions due to the recalculations*

Year	Submission 2013 [Gg CH <sub>4</sub> ]	Submission 2014 [Gg CH <sub>4</sub> ]	Difference [Gg CH <sub>4</sub> ]	Percentage change
BY	344	324	-20	-5.8%
1985	354	333	-21	-5.9%
1986	341	321	-20	-5.9%
1987	336	317	-20	-5.8%
1988	332	313	-19	-5.8%
1989	322	302	-20	-6.1%
1990	314	295	-18	-5.9%
1991	292	272	-20	-6.8%
1992	246	229	-17	-6.7%
1993	214	200	-14	-6.7%
1994	189	176	-13	-6.7%
1995	184	173	-11	-6.2%
1996	189	178	-11	-5.7%
1997	179	170	-10	-5.3%

Year	Submission 2013 [Gg CH <sub>4</sub> ]	Submission 2014 [Gg CH <sub>4</sub> ]	Difference [Gg CH <sub>4</sub> ]	Percentage change
1998	180	171	-9	-5.2%
1999	185	176	-9	-4.9%
2000	177	169	-8	-4.8%
2001	169	161	-8	-4.8%
2002	170	162	-8	-4.6%
2003	170	162	-8	-4.8%
2004	159	151	-8	-5.1%
2005	153	145	-8	-5.1%
2006	149	142	-7	-4.7%
2007	150	143	-6	-4.3%
2008	144	138	-6	-4.0%
2009	138	132	-6	-4.0%
2010	136	131	-5	-3.8%
2011	134	130	-4	-3.0%

**Table 6.1.8** *Change in the N<sub>2</sub>O emissions due to the recalculations*

Year	Submission 2013 [Gg N <sub>2</sub> O]	Submission 2014 [Gg N <sub>2</sub> O]	Difference [Gg N <sub>2</sub> O]	Percentage change
BY	38	38	-0.1	-0.3%
1985	38	37	-0.2	-0.4%
1986	38	38	-0.1	-0.3%
1987	39	39	-0.1	-0.2%
1988	37	37	0.0	0.1%
1989	36	36	0.2	0.5%
1990	29	29	0.2	0.8%
1991	22	22	0.2	0.9%
1992	19	19	0.1	0.5%
1993	17	17	0.1	0.4%
1994	19	19	0.0	0.2%
1995	17	18	0.2	0.9%
1996	18	18	0.2	1.2%
1997	18	18	0.3	1.8%
1998	19	19	0.3	1.8%
1999	19	20	0.3	1.7%
2000	19	19	0.3	1.7%
2001	20	20	0.3	1.4%
2002	20	21	0.3	1.4%
2003	20	20	0.3	1.5%
2004	21	21	0.3	1.3%
2005	19	20	0.3	1.7%
2006	20	20	0.3	1.7%
2007	20	20	0.3	1.7%
2008	20	20	0.2	1.2%
2009	18	19	0.2	1.4%
2010	18	19	0.2	1.3%
2011	19	19	0.2	0.9%

### **6.1.7 Planned improvements**

Similarly to other sectors the main goal is introduction of IPCC 2006 Guidelines in the reporting for the 2015 submission. Development of country specific values for the  $Frac_{GASF}$  and  $Frac_{GASM}$  based on the reported  $NH_3$  and  $NO_x$  emissions under UNECE/LRTRAP was planned for this inventory cycle. The country specific values has been developed for the  $Frac_{GASF}$  and  $Frac_{GASM}$ , but has not been applied yet in this submission, because the methodology for UNECE/LRTRAP as well as the GHG-inventory reporting are to be changed for the next submission, requiring a recalculation of these values again for the next submission. Thus, the country-specific values were only applied for verification in this submission.

In line with the development plan data on biogas application and anaerobic digesters has been collected in this inventory cycle for the further refinement of the estimation of  $CH_4$  emissions from 4.B Manure management. Provisional estimation of the resulting emission abatement due to biogas systems has also been done in this inventory cycle, which revealed that the effects of the biodigesters on the overall  $CH_4$  emissions in the inventory has been negligible yet in Hungary. It could be approximately 1 Gg  $CH_4$ . However, the number of the anaerobic digesters installed annually is rapidly increasing, requiring further improvements to take them into account in the inventory. On the other hand, it also revealed that the installation of the new anaerobic digesters results in additional change in the animal waste management, because dairy cattle are probably increasingly held on liquid system. Thus, the update of the AWMS data for the years after 2010 is also needed, and the harmonization of the data from the nitrate database and the waste statistics is also required.

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

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

Key source: 4A1 Cattle L1, T1

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 which primarily influencing the amount of CH<sub>4</sub> from enteric fermentation. In 2012 54% of the total CH<sub>4</sub> emissions from agriculture derived from this source category.

### 6.2.1 Source Category Description

CH<sub>4</sub> emissions from enteric fermentation amounted to 160 Gg in the base year and have reduced by 55 per cent to 72 Gg in 2012 mainly due to decrease in cattle livestock.

### 6.2.2 Methodological issues

Emissions from enteric fermentation were calculated 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).

#### 6.2.2.1 Activity Data - Livestock Population

The HCSO has been producing two censuses of animal numbers per year since 2009. One survey is conducted in June and the other in December. The annual average population for a year *t* was calculated by using the chronological mean of censuses, 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]

The method delineated above was suggested by the HCSO's expert (Tóth, 2004) to smooth out the seasonal changes in the livestock population.

Until the end of 2008 the HCSO collected data on animal livestock population three times a year, namely April, August and December. For the calculation of the annual average population for the years before 2009 the chronological mean was used similarly, based on the three surveys data.

The annual average livestock populations reported in the CRF tables and their trends are provided in Table 6.2.1-6.2.3.

As a result of two recommendations from the centralized review conducted in 2013, this chapter has been supplemented with the following information concerning the annual average livestock population of Non-Dairy Cattle and Poultry and the rounding of these values.

In case of Non-Dairy Cattle and Poultry enhanced livestock characterization is used according to the requirements of the IPCC methodology. The average annual livestock populations for these animal pieces were determined by sub-categories as well as the overall livestock category from the values supplied by the HCSO, who provides the animal livestock data rounded in thousands. Thus, the details (i.e. livestock number of sub-categories) may

not add up to the totals due to rounding in the HCSO's data. As a consequence of the rounding and the use of the chronological means, the values provided in Table 6.2.1 (i.e. values of the chronological means calculated from the overall livestock population data) may slightly differ from the sums of the values showed in Table 6.2.2 and Table 6.2.3, which include the chronological means calculated for each livestock sub-categories.

**Table 6.2.1 Livestock population and trends 1985-2012**

Source: HCSO

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	2,780	17	100	4.7	9,050	80,690	2,539
BY	590	1,234	0.1	2,584	18	96	4.8	8,963	81,739	2,537
1986	584	1,226	0.1	2,520	17	97	4.8	8,904	82,015	2,525
1987	582	1,165	0.1	2,452	19	92	4.8	8,935	82,512	2,546
1988	581	1,144	0.1	2,389	23	83	4.7	8,888	78,007	2,553
1989	574	1,116	0.1	2,249	27	76	4.5	8,540	73,248	2,523
1990	564	1,053	0.1	2,064	31	76	4.3	8,709	70,326	2,587
1991	527	1,018	0.1	2,018	35	78	4.2	7,809	58,827	2,630
1992	480	834	0.1	1,877	43	78	4.1	6,237	52,168	2,389
1993	436	649	0.1	1,541	53	73	4.1	5,805	43,429	2,149
1994	409	554	0.1	1,140	63	76	4.1	5,007	44,477	1,909
1995	395	549	0.2	993	70	76	4.1	5,023	44,875	1,669
1996	389	546	0.3	1,004	75	68	4.1	5,494	38,538	1,149
1997	388	521	0.4	898	79	71	4.1	5,013	40,417	1,071
1998	381	494	0.5	917	84	73	4.1	5,247	42,708	1,052
1999	385	489	0.6	956	88	74	4.1	5,609	40,260	1,040
2000	363	479	0.7	1,192	97	78	3.6	5,146	48,562	943
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
2011	250	440	3.7	1,141	84	73	3.5	3,120	46,069	950
2012	255	473	3.4	1,141	86	76	3.6	2,952	42,908	1,070
Trend BY-2012	-58%	-64%	3565%	-56%	376%	-24%	-28%	-65%	-44%	-63%

**Table 6.2.2** *Livestock population and trends for non-dairy cattle (1'000 head)*

Year	<1 year		1-2 year		>2 year			
	Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
1985	273	280	243	297	72	22	21	103
BY	257	264	226	278	72	20	20	97
1986	255	263	223	277	73	20	19	95
1987	243	249	212	259	72	19	18	93
1988	242	247	211	255	70	19	18	83
1989	229	247	191	262	68	18	17	83
1990	213	241	170	257	66	17	16	74
1991	205	238	162	252	62	16	15	68
1992	164	207	111	219	55	13	11	54
1993	129	163	86	171	45	10	7	39
1994	109	144	68	151	41	8	5	28
1995	107	143	66	149	43	8	5	28
1996	105	139	70	144	44	8	5	30
1997	100	133	64	139	47	7	4	27
1998	99	132	41	137	50	7	4	24
1999	97	130	48	136	44	7	4	23
2000	96	132	36	136	42	6	3	27
2001	88	126	29	131	37	5	3	24
2002	85	125	27	130	37	5	2	23
2003	88	122	27	125	36	5	2	30
2004	82	114	25	122	34	6	3	39
2005	85	109	23	119	33	6	2	44
2006	85	107	30	117	31	6	3	51
2007	87	106	37	116	33	6	2	55
2008	79	110	32	115	32	6	2	61
2009	82	108	32	120	33	7	2	62
2010	76	108	35	121	36	7	3	69
2011	75	106	27	116	36	7	3	73
2012	87	113	32	117	36	7	4	78
Trend BY-2012	-66%	-57%	-86%	-58%	-51%	-66%	-79%	-19%

Source: HCSO

**Table 6.2.3 Livestock population and trends for Poultry**

Year	Poultry Population (1,000 head)					
	Laying hens	Chickens, Hens, Cocks	Geese	Ducks	Turkeys	Guinea-Fowls
1985	24,397	49,956	1,875	2,693	1,484	285
BY	24,485	50,939	1,814	2,718	1,420	363
1986	24,402	51,045	1,891	2,744	1,513	420
1987	24,655	51,817	1,676	2,716	1,264	384
1988	23,314	48,485	1,931	2,712	1,321	245
1989	23,045	42,913	2,677	2,685	1,686	241
1990	22,735	40,178	2,926	2,464	1,773	250
1991	23,460	29,488	2,167	2,217	1,253	243
1992	20,187	27,393	1,459	1,970	917	243
1993	19,314	19,290	1,494	2,008	1,080	243
1994	17,093	21,667	1,855	2,339	1,289	235
1995	15,733	23,349	1,834	2,145	1,599	215
1996	16,368	16,431	1,616	1,955	1,979	188
1997	15,491	18,816	1,635	2,140	2,157	178
1998	15,824	20,158	1,624	2,726	2,157	219
1999	15,255	17,749	1,690	3,222	2,084	260
2000	13,744	24,224	3,080	3,250	4,030	234
2001	15,397	25,290	2,916	3,790	3,449	233
2002	16,052	23,328	3,474	4,490	3,790	200
2003	16,385	23,645	3,986	4,771	3,496	203
2004	15,399	23,187	3,177	3,898	4,637	193
2005	14,232	22,058	2,183	3,704	4,037	190
2006	14,425	20,269	2,387	3,117	4,270	185
2007	13,064	20,359	2,375	2,781	4,431	151
2008	13,376	21,866	2,488	3,070	4,071	162
2009	12,732	22,365	2,385	3,736	3,422	149
2010	12,545	23,164	2,211	5,155	3,365	148
2011	11,461	23,691	2,422	5,209	3,153	134
2012	11,089	21,992	2,234	4,430	3,025	140
Trend BY-2012	-53%	-53%	33%	92%	122%	-63%

Source: HCSO

**6.2.2.2 Cattle**Emitted gas: CH<sub>4</sub>

Key source: Level 1; Trend 1;

**Emission Factors**

CH<sub>4</sub> emissions from enteric fermentation in Dairy Cattle and Non-Dairy Cattle categories were calculated using the Tier 2 method (GPG, Equation 4.14):

$$EF = (GE * Y_m * 365) / 55.65 \quad (\text{Equation 6.2})$$

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 in Dairy Cattle**

Until the previous submission the country-specific values of gross energy intake was calculated based on the WINLP (Hungarian nutrition optimization software for dairy cow). Although it is known, that the software use the Hungarian standards of animal nutrition, but detailed documentation containing the equations used in it is unavailable. Thus, the recommendations from the formal annual reviews to provide more detailed methodological description on the equations used in the software were unsolvable.

To meet the ERT requirements, in the course of a research project conducted in the last year a more transparent methodology was developed for the calculation of gross energy intake. The new results based on feed intake data of the Research Institute on the Agricultural Economics and energy content of feed provided in the Hungarian Nutrition Codex (2004). Hence, the new results are more reliable than the previous one, using statistics instead of the former standards.

The feed intake statistics provides annual data on the composition of the diet per 1000 kg milk basis, from which the feed intake can be calculated using the annual milk yields. The additional advantage of the new results that the calculation takes into account the difference between the energy requirements of the Holstein-Friesian and Hungarian Simmental, which are the most widespread dairy cattle breeds in Hungary. Moreover, seasonal changes in the feeding practices were also taken into account.

Data on the composition of the diet enabled us to calculate the Digestible Energy for each year, as a weighted average of the digestibility of each component in the diet. The digestibility values were taken from the 'feed database' provided in the Hungarian Nutrition Codex (2004). This database contains the laboratory measurements of the feed used for animal nutrition in Hungary.

To ensure the closest conformity with the IPCC methodology the calculation of the gross energy intake based on the Equation 4.11 of GPG (IPCC, 2000). The sources of the terms used in the equations are summarized in Table 6.2.4.

For the estimation of gross energy intake the average body mass of dairy-cattles was determined for each year of the time-series based on the change of the livestock composition and the characteristics of species in the new research results (Kovács, 2013). 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 also had an importance. Proportions of Jersey and Ayrshire can be considered as negligible. Since 1985 the proportion of the Hungarian Simmental species has been dropped and as a result the milk yield increased from 4518 kg per year to 6429 kg per year in the period 1985-2005, together with this change the average body weight in the herd also increased. The annual average body mass was calculated from the typical body mass of the two main species and their proportions in the certain year based on HCSO statistics. The typical body mass of Holstein-Friesian and Hungarian Simmental is assumed to be 650 and 550 kg in the calculation. The resulted body weights by years are shown in Table 6.2.5.

The daily average milk yield (19.5 kg per day in 2012) was calculated based on the HCSO's annual milk yield statistics (see Table 6.2.5). The annual milk fat and nutrition content data was taken from the Eurostat statistics for the period 1998-2012, while for the period 1985-1997 the average of the values provided for the period 1998-2012 were assumed due to lack of statistical data.

**Table 6.2.4** Parameters and equations used to estimate the GE for Dairy-Cattle

Activity data, parameters and coefficients	Unit	Source	Values/ Notes
Weight	kg	Kovács, 2013	Calculated annually, based on the ratio and the body mass of Hungarian species.
C <sub>f</sub> , Coefficient for Eq. 4.3a of GPG(IPCC, 2000)		Table 4.4 of GPG (IPCC, 2000)	0.335 (Cattle, lactating)
C <sub>pregnancy</sub>		Table 4.7 of GPG (IPCC, 2000)	0.1
Digestible energy intake (DE)	%	Kovács, 2013	Calculated based on feeding statistics and laboratory measurements.
C <sub>a</sub>		Table 4.5 of GPG (IPCC, 2000)	0 for stall, 0.17 for pasture
proportion for grazing		HCSO, agricultural surveys, NFCO's Nitrate database	See also Chapter 6.3.
NE <sub>m</sub>	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian net energy requirements standards. Calculated separately for Holstein-Friesian and Hungarian Simmental
NE <sub>a</sub>	MJ/day	Eq. 4.2a of GPG (IPCC, 2000)	calculated
NE <sub>i</sub>	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian net energy requirements standards.
NE <sub>p</sub>	MJ/day	Eq. 4.8 of GPG (IPCC, 2000)	calculated
NE <sub>ma</sub> /DE		Eq. 4.9 GPG (IPCC, 2000)	calculated
GE	MJ/day	Eq. 4.11 of GPG (IPCC, 2000)	calculated
Y <sub>m</sub>		Kovács, 2013	calculated

The Hungarian Nutrition Codex (2004) provides standards for the calculation of net energy requirements for different animal species, among these for Dairy-Cattles. The Hungarian standards are similar to the American net energy system, although the calculation methodologies of NE<sub>i</sub> and NE<sub>m</sub> differ from that. In the course of the research project the value of NE<sub>i</sub> and NE<sub>m</sub> were determined based on the Equation 4.1 and Equation 4.5a of the GPG (IPCC, 2000) as well as the Hungarian Nutrition Codex (2004). The use of the Hungarian standards for NE<sub>i</sub> and NE<sub>m</sub> indicated higher values for the GE than the IPCC methodology. Thus, the NE<sub>i</sub> and NE<sub>m</sub> were calculated using the Hungarian standards for the inventory purposes, because it was assumed that it is more reliable for the Hungarian species, on one hand. On the other hand, it can be considered as a conservative approach, resulting in higher GE and EF than the IPCC methodology.

**Table 6.2.5** *Body mass, digestible energy, milk yield, gross energy intake, N-excretion and emission factor for Dairy-Cattle*

Year	Body Mass, Average	Digestible Energy	Milk Yield	Gross Energy Intake	N-excretion	Emission Factor for 4.A
	kg/head	%	kg/ head*year	MJ/head*day	kg N / head*year	kg CH <sub>4</sub> / head*year
1985	626	68.29	12.28	251	74	105
BY	628	68.53	12.80	254	76	106
1986	628	68.55	12.91	255	77	107
1987	629	68.75	13.21	255	79	107
1988	631	68.79	13.50	257	79	107
1989	632	69.10	13.62	255	82	106
1990	633	69.26	13.78	255	83	106
1991	636	69.25	12.91	246	81	102
1992	639	69.38	13.10	246	82	102
1993	641	69.41	13.03	244	82	101
1994	641	69.42	12.92	243	82	101
1995	641	69.90	13.67	247	88	102
1996	640	69.93	13.87	249	89	103
1997	640	69.97	14.01	250	90	103
1998	641	70.26	15.10	257	94	106
1999	639	70.18	14.94	257	94	106
2000	641	70.51	16.13	264	97	108
2001	641	70.58	16.58	267	99	109
2002	641	70.62	16.86	270	100	111
2003	642	70.64	16.86	271	100	111
2004	642	70.60	16.80	270	101	110
2005	642	70.75	17.61	273	104	112
2006	642	70.81	18.37	280	106	115
2007	642	70.76	18.83	285	107	117
2008	642	70.51	19.10	289	104	119
2009	642	70.35	18.67	288	104	118
2010	642	70.27	18.84	288	103	119
2011	642	69.53	18.77	291	99	120
2012	642	69.67	19.53	297	100	123

**Methane conversion rate for dairy cattle**

Following a potential recommendation from the previous annual review country-specific factor were developed for the value of  $Y_m$  for Dairy Cattle based on the data on composition of diet used for the estimation of GE.

Laboratory measurements on  $Y_m$ , similarly to most of the other party, is unavailable in Hungary, therefore the country-specific values were calculated based on the IPCC default values, and values reported by other European countries. The following assumptions were made:

The GPG (IPCC, 2000) suggests a value of  $0.04 \pm 0.005$  for feedlot cattle, when diets contain 90 per cent or more concentrates and a value of  $0.06 \pm 0.005$  for all other cattle. The Guidelines (IPCC, 2006) indicate a wider range for this value,  $3\% \pm 1\%$  for feedlot cattle and  $6.5\% \pm 1\%$  for other Dairy Cows. The study of Soliva (2006) also suggests higher values than the GPG (IPCC, 2000), namely 6.2%-7.4%, depending on the concentrate ratio in the diet. The EU reports an average value of 6.05 for  $Y_m$ . Although the concentrate ratio is unknown

to this value, but the high value of DE=70% indicates a relatively high concentrate ratio.

In the Hungarian inventory the concentrate ratio varies between 21 and 37 per cent over the period 1985-2012. Thus, taking into account the IPCC default values and the values reported by other European countries the  $Y_m$  were calculated by linear interpolation, in dependency of the concentrate ratio.  $Y_m=6.2$  was assumed to the value of 40% concentrate ratio and a value of 6.4 to the 20%. The results are shown in Table 6.2.6

**Table 6.2.6 Methane Conversion Rates for dairy cattle 1985-2012**

Year	Concentrate Ratio	$Y_m$
	%	%
1985	0.21	6.39
BY	0.22	6.38
1986	0.23	6.37
1987	0.24	6.36
1988	0.24	6.36
1989	0.26	6.34
1990	0.28	6.32
1991	0.28	6.32
1992	0.29	6.31
1993	0.29	6.31
1994	0.29	6.31
1995	0.32	6.28
1996	0.32	6.28
1997	0.32	6.28
1998	0.34	6.26
1999	0.34	6.26
2000	0.36	6.24
2001	0.36	6.24
2002	0.36	6.24
2003	0.36	6.24
2004	0.36	6.24
2005	0.37	6.23
2006	0.36	6.24
2007	0.36	6.24
2008	0.34	6.26
2009	0.33	6.27
2010	0.33	6.27
2011	0.29	6.31
2012	0.30	6.30

*Note: Concentrate ratio means the proportion of concentrate in the dry matter intake*

### Gross energy intake for non-dairy cattle

Gross energy intakes for non-dairy cattle were derived from the new research results (Kovács, 2013), where the typical Hungarian diets for each sub-category of non-dairy cattle was determined. Besides, the seasonal changes in the diets were also taken into account for each sub-category. In the calculation the available data, the Hungarian technological standards and expert opinions were combined to get the most reliable results. Similarly, to the Dairy-Cattle the values of  $NE_m$  and  $NE_l$  for Other Cattle were calculated according to the Hungarian standards. Table 6.2.7 summarizes the parameters and equations used to estimate the gross energy intake for non-dairy cattle.

**Table 6.2.7** Parameters and equations to estimate the gross energy intakes for non-dairy cattle

Activity data, parameters and coefficients	Unit	Sources	Values/ Notes
Weight	kg	Kovács, 2013	Calculated based on the livestock composition.
$C_{fi}$ , Coefficient for Eq. 4.3a of GPG(IPCC, 2000)		Table 4.4 of GPG (IPCC, 2000)	0.335 for Beef Cattle, 0.322 for other Cattle
Weight Loss			NO
WG (daily weight gain)	kg	Kovács, 2013	1 for male<1 year, 0.73 for female<1 year, 0.65 for heifers, 0.9 for bovines 1-2 years, 0 for mature
$C$ , Coefficient for Eq. 4.3a of GPG(IPCC, 2000)		GPG (IPCC, 2000)	0.8 for females, 1.2 for bulls, 0 for mature
$C_{pregnancy}$		Table 4.7 of GPG (IPCC, 2000)	0.1
Digestible energy intake (DE)	%	Kovács, 2013	Calculated based on fed diets and laboratory measurements
$C_a$		Table 4.5 of GPG (IPCC, 2000)	0 for stall, 0.17 for pasture
proportion for grazing		HCSO, agricultural surveys, NFCSO's Nitrate database	
$NE_m$	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian net energy requirements standards.
$NE_a$	MJ/day	Eq. 4.2a of GPG (IPCC, 2000)	calculated
$NE_l$	MJ/day	Hungarian Nutrition Codex, 2004	Country-specific methodology according to the Hungarian net energy requirements standards.
$NE_g$	MJ/day	Eq. 4.3a of GPG (IPCC, 2000)	calculated
$NE_p$	MJ/day	Eq. 4.8 of GPG (IPCC, 2000)	calculated
$NE_{ma}/DE$		Eq. 4.9 GPG (IPCC, 2000)	calculated
$NE_{ga}/DE$		Eq. 4.10 of GPG (IPCC, 2000)	calculated
GE	MJ/day	Eq. 4.11 of GPG (IPCC, 2000)	calculated

Following a recommendation of the centralized review 2013, additional information on the source of the body mass of Non-Dairy Cattle has been included to the NIR (see below).

For the estimation of the gross energy intake the body mass was also determined in the new research results (Kovács, 2013) for each sub-category. The typical body mass for each sub-category as well as the resulted gross energy intake and the emission factors for the BY and the year 2012 are shown in Table 6.2.8 and Table 6.2.9.

**Table 6.2.8** Gross energy intakes and emission factors by non-dairy cattle sub-categories for the base year

BY		<1 year		1-2 year		>2 year			
		Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
Live weight	kg	195	170	415	370	515	575	530	600
Digestible Energy	%	69	71	62	62	69	66	67	69
N-excretion	kg N / head *	42	41	40	31	61	56	53	70
Gross Energy Intake	MJ / head *	94	92	156	160	200	192	185	157
Concentrate ratio	%	31%	33%	10%	12%	18%	17%	17%	16%
Y <sub>m</sub>	%	5.26	5.24	6.50	6.48	6.42	6.43	6.43	6.44
Emission Factor for 4.A	kg CH <sub>4</sub> / head *	23	22	66	68	84	81	78	66

**Table 6.2.9** Gross energy intakes and emission factors by non-dairy cattle sub-categories for the year 2012

2012		<1 year		1-2 year		>2 year			
		Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
Live weight	kg	195	170	415	370	515	575	530	600
Digestible Energy	%	69	70	61	62	68	65	65	67
N-excretion	kg N / head *	44	42	46	41	66	60	57	75
Gross Energy Intake	MJ / head *	94	94	161	163	192	199	191	162
Concentrate ratio	%	30%	33%	10%	12%	18%	17%	17%	17%
Y <sub>m</sub>	%	5.26	5.24	6.50	6.48	6.42	6.43	6.43	6.43
Emission Factor for 4.A	kg CH <sub>4</sub> / head *	23	23	69	69	81	84	80	68

**Methane conversion rate for non-dairy cattle**

Methane conversion rate for non-dairy cattle was calculated similarly to the dairy cattle. The country-specific values were obtained by linear interpolation in dependency of the proportion

of concentrate in the dry matter intakes. In case of 'Bovines < 1 year' for the period of consuming milk methane conversion rate zero was assumed in accordance with the GPG (IPCC, 2000).

### 6.2.2.3 Other livestock categories

Key source: None

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. It is assumed that the Hungarian housing and feeding practices do not differ from the Italian ones.

Emission factor for poultry was taken from the literature; due to lack of IPCC default values. Sources of emission factors per livestock species are summarized in Table 6.2.10.

**Table 6.2.10** 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
Buffalo	55	IPCC default value for developed countries
Sheep	8	IPCC default value for developed countries
Goats	5	IPCC default value for developed countries
Horses	18	IPCC default value for developed countries
Asses & Mules	10	IPCC default value for developed countries
Swine	1.5	IPCC default value for developed countries
Poultry	0.015	expert judgement, according to Minonzio et al. (1998)
Rabbits	0.08	expert judgement, according to 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 6.1.3) 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 Source specific QA/QC information

The country specific value of the net energy intake for Dairy-Cattles was verified using values reported by the EU member states. The net energy intake for the EU member states was calculated from the gross energy intake using the equations of the GPG (IPCC, 2000). It was revealed that the Hungarian value (109 MJ head<sup>-1</sup> d<sup>-1</sup>) was consistent with that reported by other EU's countries. The average net energy intake for the EU-15 member states was 113 MJ head<sup>-1</sup> d<sup>-1</sup> according to the NIR submissions, 2013. There are no difference between the

milk production in Hungary and in the EU-15. The milk production for the year 2011 was about 19 kg both for the EU-15 and Hungary. The feed digestibility was 72% in the EU-15, while 70% in Hungary.

### 6.2.5 Source-specific recalculations

As a consequence of the new research results (Kovács, 2013) emissions from 4.A Enteric Fermentation in Cattle were revised for the whole time-series. One of the aims of the research was to get more reliable values for gross energy intake for dairy as well as for non-dairy cattle. The revised estimates resulted in lower values for the live weight and the digestible energy leading to lower estimates for the gross energy intake and the annual emission factors.

Table 6.2.11 and 6.2.12 summarize the change in the live weight, digestible energy, gross energy intake and the emission factors for the Dairy and Non-Dairy Cattle, respectively.

**Table 6.2.11** Recalculation of gross energy intake for Dairy-Cattle

Year	Live Weight kg			DE			GE MJ/head			EF kg CH <sub>4</sub> /head		
	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.
1985	600	626	26	66	68	3	258	251	-7	102	105	4
BY	603	628	25	66	69	3	262	254	-9	103	106	3
1986	603	628	25	66	69	3	263	255	-8	104	107	3
1987	605	629	24	66	69	3	265	255	-10	104	107	2
1988	608	631	23	66	69	3	267	257	-10	105	107	2
1989	610	632	22	66	69	3	269	255	-14	106	106	0
1990	613	633	21	66	69	3	271	255	-16	106	106	-1
1991	615	636	21	66	69	3	271	246	-25	107	102	-5
1992	618	639	22	66	69	3	271	246	-25	107	102	-5
1993	620	641	21	66	69	3	271	244	-27	107	101	-6
1994	623	641	19	66	69	3	271	243	-28	107	101	-6
1995	625	641	16	66	70	4	271	247	-24	107	102	-5
1996	628	640	12	66	70	3	273	249	-24	108	103	-5
1997	630	640	10	67	70	3	275	250	-25	108	103	-5
1998	633	641	8	67	70	4	277	257	-20	109	106	-4
1999	635	639	4	67	70	3	279	257	-22	110	106	-4
2000	638	641	4	67	71	4	281	264	-17	111	108	-3
2001	640	641	1	67	71	3	285	267	-18	112	109	-3
2002	643	641	-2	67	71	3	289	270	-18	114	111	-3
2003	645	642	-3	68	71	3	292	271	-22	115	111	-4
2004	648	642	-6	68	71	3	296	270	-26	116	110	-6
2005	650	642	-8	68	71	3	299	273	-26	118	112	-6
2006	650	642	-8	68	71	2	305	280	-25	120	115	-5
2007	650	642	-8	69	71	2	308	285	-22	121	117	-4
2008	650	642	-8	69	71	2	310	289	-21	122	119	-3
2009	650	642	-8	69	70	2	309	288	-22	122	118	-3
2010	650	642	-8	69	70	1	310	288	-22	122	119	-4
2011	650	642	-8	69	70	1	310	291	-19	122	120	-1

**Table 6.2.12** Recalculation of gross energy intake for Non-Dairy Cattle

Year	Live Weight kg			DE %			GE MJ/head			EF kg CH <sub>4</sub> /head		
	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.	Subm. 2013	Subm. 2014	diff.
1985	352	331	-21	63	67	3	150	134	-17	59	50	-9
BY	352	331	-21	63	67	3	150	134	-17	58	50	-9
1986	352	331	-21	63	67	3	150	134	-17	58	49	-9
1987	353	332	-21	63	67	3	150	134	-16	58	50	-9
1988	351	329	-21	63	67	3	150	134	-17	58	49	-9
1989	349	329	-19	64	67	3	149	134	-16	58	49	-9
1990	343	327	-16	64	66	3	147	134	-14	57	49	-8
1991	337	325	-12	63	66	3	146	133	-13	57	49	-8
1992	333	322	-11	64	67	3	144	132	-12	56	49	-7
1993	330	319	-11	64	67	2	143	132	-11	56	48	-7
1994	325	316	-9	64	67	2	142	132	-10	55	48	-7
1995	324	316	-8	64	67	2	141	132	-9	55	48	-7
1996	324	320	-4	64	66	3	140	133	-7	54	49	-6
1997	319	320	1	65	66	2	138	133	-5	54	49	-5
1998	323	315	-8	65	67	1	140	133	-7	54	48	-6
1999	317	314	-3	65	66	2	138	132	-6	54	48	-5
2000	320	312	-9	65	66	2	138	131	-6	53	48	-6
2001	317	309	-8	65	66	2	137	131	-6	53	47	-6
2002	316	308	-8	65	66	2	137	131	-6	53	47	-6
2003	321	313	-9	65	67	2	137	132	-6	53	47	-6
2004	331	322	-9	65	66	2	138	133	-5	54	49	-5
2005	334	324	-10	65	67	2	138	133	-5	54	49	-5
2006	342	331	-11	64	66	2	139	134	-5	54	49	-5
2007	346	334	-12	64	66	2	140	135	-5	54	50	-5
2008	350	338	-12	64	66	2	140	135	-5	54	50	-5
2009	350	339	-12	64	66	2	140	136	-5	55	50	-4
2010	360	347	-13	64	66	2	142	138	-4	55	51	-4
2011	362	349	-13	64	66	2	141	138	-3	55	51	-4

Although revision of GE for Cattle resulted in many changes in the details of the calculations the overall changes in the CH<sub>4</sub> emissions from 4.A is not significant. It resulted in an overall decrease of emissions of 5.5 per cent in the BY and 2.7 per cent in 2011 (Table 6.2.13 and Table 6.2.14).

**Table 6.2.13** *Effects of recalculation of emissions from Dairy-Cattle on the 4.A*

Year	GE MJ/head		Diff.	EF kg CH <sub>4</sub> /head		Diff.
	Submission 2013	Submission 2014		Submission 2013	Submission 2014	
1985	258	251	7	102	105	-4
BY	262	254	9	103	106	-3
1986	263	255	8	104	107	-3
1987	265	255	10	104	107	-2
1988	267	257	10	105	107	-2
1989	269	255	14	106	106	0
1990	271	255	16	106	106	1
1991	271	246	25	107	102	5
1992	271	246	25	107	102	5
1993	271	244	27	107	101	6
1994	271	243	28	107	101	6
1995	271	247	24	107	102	5
1996	273	249	24	108	103	5
1997	275	250	25	108	103	5
1998	277	257	20	109	106	4
1999	279	257	22	110	106	4
2000	281	264	17	111	108	3
2001	285	267	18	112	109	3
2002	289	270	18	114	111	3
2003	292	271	22	115	111	4
2004	296	270	26	116	110	6
2005	299	273	26	118	112	6
2006	305	280	25	120	115	5
2007	308	285	22	121	117	4
2008	310	289	21	122	119	3
2009	309	288	22	122	118	3
2010	310	288	22	122	119	4
2011	310	291	19	122	120	1

**Table 6.2.14** *Effects of recalculation of emissions from Non-Dairy-Cattle on the 4.A*

Year	GE MJ/head		Diff.	EF kg CH <sub>4</sub> /head		Diff.
	Submission 2013	Submission 2014		Submission 2013	Submission 2014	
1985	150	134	17	59	50	9
BY	150	134	17	58	50	9
1986	150	134	17	58	49	9
1987	150	134	16	58	50	9
1988	150	134	17	58	49	9
1989	149	134	16	58	49	9
1990	147	134	14	57	49	8
1991	146	133	13	57	49	8
1992	144	132	12	56	49	7
1993	143	132	11	56	48	7
1994	142	132	10	55	48	7
1995	141	132	9	55	48	7
1996	140	133	7	54	49	6
1997	138	133	5	54	49	5
1998	140	133	7	54	48	6
1999	138	132	6	54	48	5
2000	138	131	6	53	48	6
2001	137	131	6	53	47	6
2002	137	131	6	53	47	6
2003	137	132	6	53	47	6
2004	138	133	5	54	49	5
2005	138	133	5	54	49	5
2006	139	134	5	54	49	5
2007	140	135	5	54	50	5
2008	140	135	5	54	50	5
2009	140	136	5	55	50	4
2010	142	138	4	55	51	4
2011	141	138	3	55	51	4

### 6.2.6 Planned improvements

Implementation of the methodology of the 2006 IPCC Guidelines.

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

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

Key source categories (CH<sub>4</sub>): Level 1 ; Trend 1

(N<sub>2</sub>O): 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.

#### 6.3.1 Source Category Description

In 2012 45% (CH<sub>4</sub>) and 14% (N<sub>2</sub>O) of the agricultural emissions arose from this source category. The bulk of the CH<sub>4</sub> emissions are generated in cattle and swine husbandry, due to the considerable share of liquid manure and deep litter. The main source of N<sub>2</sub>O emissions are the solid and 'other' systems containing deep litter and 'Poultry manure'.

CH<sub>4</sub> emissions from manure management have declined by 62% since the BY, which reflects the significant decrease in swine livestock (Table 6.3.1).

**Table 6.3.1** Trend in CH<sub>4</sub> emissions from 4.B Manure Management

Year	Total	Dairy Cattle	Non-Dairy Cattle	Buffalo	Sheep	Goats	Horses	Mules and Asses	Swine	Poultry	Other Animals (Rabbits)
	Gg CH <sub>4</sub> yr-1										
1985	162.2	27.3	31.1	0.0001	0.64	0.003	0.143	0.004	98.4	4.37	0.20
BY	158.9	26.7	29.3	0.0001	0.61	0.003	0.137	0.004	97.5	4.39	0.20
1986	157.8	26.6	29.1	0.0001	0.60	0.003	0.138	0.004	96.9	4.39	0.20
1987	156.6	26.3	27.7	0.0001	0.60	0.003	0.130	0.004	97.2	4.42	0.20
1988	155.4	26.5	27.1	0.0001	0.57	0.004	0.111	0.004	96.7	4.19	0.20
1989	150.1	25.7	26.5	0.0001	0.53	0.005	0.109	0.004	92.9	4.13	0.20
1990	149.7	25.1	25.0	0.0001	0.48	0.005	0.111	0.003	94.7	4.06	0.21
1991	136.4	22.6	24.0	0.0001	0.49	0.006	0.117	0.003	84.9	4.02	0.21
1992	112.1	20.5	19.5	0.0001	0.46	0.008	0.109	0.003	67.8	3.46	0.19
1993	100.7	18.5	15.1	0.0001	0.36	0.009	0.103	0.003	63.1	3.26	0.17
1994	88.1	17.2	12.9	0.0001	0.27	0.011	0.118	0.003	54.5	2.97	0.15
1995	87.4	16.7	12.8	0.0002	0.25	0.012	0.103	0.003	54.6	2.80	0.13
1996	92.5	16.6	12.9	0.0003	0.23	0.012	0.102	0.003	59.8	2.84	0.09
1997	86.6	16.5	12.3	0.0004	0.22	0.013	0.105	0.003	54.5	2.75	0.09
1998	88.4	16.6	11.5	0.0005	0.23	0.014	0.106	0.003	57.1	2.82	0.08
1999	92.4	16.8	11.4	0.0006	0.24	0.015	0.108	0.003	61.0	2.72	0.08
2000	86.2	16.0	11.0	0.0007	0.29	0.015	0.108	0.003	56.0	2.69	0.08
2001	81.9	15.7	10.3	0.0008	0.28	0.016	0.094	0.003	52.7	2.76	0.09
2002	84.1	15.5	10.1	0.0009	0.27	0.014	0.088	0.003	55.4	2.70	0.09
2003	83.9	14.8	10.2	0.0010	0.28	0.013	0.087	0.002	55.9	2.57	0.09
2004	75.4	13.8	10.2	0.0010	0.31	0.012	0.090	0.002	48.5	2.31	0.09
2005	70.7	13.5	10.2	0.0011	0.31	0.011	0.093	0.002	44.6	1.94	0.08
2006	69.4	12.7	10.6	0.0012	0.28	0.011	0.090	0.002	43.9	1.79	0.09
2007	70.7	12.5	11.0	0.0013	0.27	0.009	0.082	0.002	45.2	1.53	0.08
2008	66.5	12.6	11.0	0.0013	0.25	0.009	0.081	0.001	41.2	1.40	0.07
2009	61.8	12.3	11.3	0.0014	0.24	0.008	0.083	0.001	36.6	1.21	0.07
2010	61.2	11.7	11.7	0.0024	0.22	0.009	0.091	0.002	36.3	1.11	0.07
2011	60.4	12.4	11.3	0.0035	0.21	0.010	0.102	0.003	35.3	1.08	0.08
2012	59.6	12.8	12.0	0.0032	0.21	0.010	0.106	0.003	33.4	1.00	0.09
Share in 2012	100%	22%	20%	0%	0%	0%	0%	0%	56%	2%	0%
Trend BY-2012	-62%	-52%	-59%	3250%	-65%	237%	-23%	-30%	-66%	-77%	-58%

Similarly to the CH<sub>4</sub>, the N<sub>2</sub>O emissions from manure management also show a clear downward trend following the decreasing cattle, poultry and swine livestock. The N<sub>2</sub>O emissions have fallen by 56% over the inventory period (Table 6.3.2).

**Table 6.3.2** Trend in N<sub>2</sub>O emissions from 4.B Manure Management

Year	Total	Dairy Cattle	Non-Dairy Cattle	Buffalo	Sheep	Goats	Horses	Mules and Asses	Swine	Poultry	Other Animals (Rabbits)
Gg N <sub>2</sub> O yr-1											
1985	6.39	1.24	1.46	0.0001	0.98	0.006	0.163	0.002	0.92	1.29	0.33
BY	6.30	1.25	1.39	0.0001	0.95	0.006	0.156	0.002	0.91	1.31	0.33
1986	6.26	1.24	1.38	0.0001	0.93	0.006	0.158	0.002	0.90	1.32	0.33
1987	6.24	1.27	1.32	0.0001	0.93	0.007	0.148	0.002	0.91	1.33	0.33
1988	6.03	1.27	1.29	0.0001	0.88	0.009	0.126	0.002	0.87	1.25	0.33
1989	5.85	1.30	1.26	0.0001	0.82	0.010	0.124	0.002	0.83	1.16	0.33
1990	5.66	1.30	1.19	0.0001	0.74	0.012	0.126	0.002	0.84	1.11	0.33
1991	5.25	1.19	1.15	0.0001	0.76	0.013	0.133	0.002	0.77	0.90	0.34
1992	4.61	1.09	0.94	0.0001	0.71	0.017	0.124	0.002	0.62	0.80	0.31
1993	3.91	0.99	0.73	0.0001	0.55	0.020	0.118	0.002	0.57	0.65	0.28
1994	3.54	0.93	0.62	0.0001	0.41	0.024	0.134	0.002	0.49	0.68	0.25
1995	3.52	0.97	0.62	0.0003	0.38	0.025	0.118	0.002	0.49	0.70	0.22
1996	3.35	0.96	0.62	0.0004	0.35	0.027	0.116	0.002	0.53	0.58	0.15
1997	3.30	0.97	0.60	0.0005	0.34	0.029	0.119	0.002	0.48	0.62	0.14
1998	3.38	1.00	0.57	0.0007	0.36	0.030	0.121	0.002	0.50	0.66	0.14
1999	3.39	1.00	0.56	0.0008	0.37	0.032	0.123	0.002	0.54	0.62	0.13
2000	3.54	0.98	0.55	0.0009	0.45	0.032	0.123	0.002	0.49	0.78	0.12
2001	3.45	0.96	0.50	0.0011	0.44	0.035	0.104	0.002	0.45	0.82	0.14
2002	3.41	0.94	0.48	0.0012	0.42	0.030	0.095	0.002	0.47	0.82	0.15
2003	3.40	0.89	0.48	0.0013	0.45	0.029	0.091	0.002	0.48	0.83	0.14
2004	3.29	0.83	0.47	0.0015	0.50	0.025	0.091	0.001	0.41	0.81	0.15
2005	3.18	0.82	0.48	0.0016	0.51	0.022	0.092	0.001	0.37	0.75	0.13
2006	3.05	0.77	0.48	0.0017	0.48	0.022	0.086	0.001	0.36	0.71	0.14
2007	2.98	0.75	0.49	0.0018	0.45	0.019	0.076	0.001	0.37	0.70	0.14
2008	2.89	0.71	0.48	0.0018	0.43	0.018	0.073	0.001	0.34	0.73	0.12
2009	2.81	0.68	0.48	0.0019	0.42	0.015	0.072	0.001	0.30	0.73	0.11
2010	2.78	0.64	0.48	0.0033	0.40	0.018	0.077	0.001	0.29	0.77	0.12
2011	2.74	0.62	0.46	0.0048	0.38	0.019	0.086	0.002	0.28	0.76	0.12
2012	2.75	0.65	0.50	0.0044	0.38	0.020	0.089	0.002	0.27	0.71	0.14
Share in 2012	100%	24%	18%	0%	14%	1%	3%	0%	10%	26%	5%
Trend BY-2012	-56%	-48%	-64%	3250%	-60%	202%	-43%	-30%	-71%	-46%	-58%

## 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 using Tier 1 methods, although in

the case of the annual N-excretion, country-specific coefficients were used for Dairy Cattle, Non-Dairy Cattle and Swine.

### **Manure Management System Distribution**

Until 2012 submission a study, based on the HCSO's General Agricultural Census 2000 (Ráki, 2003), was applied for the manure management system distribution for the whole time-series. The activity data used for emission calculations were determined on the basis of the ratios of stall places provided in the study supplemented with expert judgments (Mészáros, 2000) and (Pazsiczky, 2008). These data were updated by a new survey for sheep and goats in 2011 (Borka et al., 2010).

Following the recommendations from the annual reviews conducted in the years 2010 to 2012 the AWMS data had to be supplied with current data in 2013. The results of the HCSO's General Agricultural Census 2010 provided an opportunity to update the information on the manure management distribution. The census produced data on housing practices for cattle, swine and laying hens, and in addition on grazing for all animal species for the year 2010. The surveyed housing systems are as follows:

#### **Cattle**

- Solid and liquid manure
- Liquid
- Other

#### **Swine**

- Partial grid floor
- Grid floor
- Deep litter
- Other

#### **Poultry**

- Deep litter
- Cage with manure belt
- Cage with pit
- Battery cage with stilt house
- Other battery cage
- Other

The dataset was a result of a comprehensive survey, but unfortunately it had not provided sufficient information for GHG inventory purposes. Therefore the HCSO's dataset needed to be harmonized with the Nitrogen Database of the National Food Chain Safety Office (NFCO) to get the required activity data.

The data collection for the Nitrogen Database is based on the Decree of the Ministry of Agriculture and Rural Development No. 59/2008 (IV. 29). The Annex 6 of the Decree contains a questionnaire. Data supply obligation is prescribed for farmers, whose animal production exceeds the household requirements.

The first version of this Decree (Government Decree No. 49/2001 (IV. 3)) entered into force in 2001. The collected data are stored in a database since 2003. This database contains data for cattle and swine by sub-categories, poultry (laying hens, cocks and broilers, ducks, geese, turkey), sheep and goats, horse. Six different management systems are distinguished: liquid, solid, deep litter, grazing, farmyard/paddock and other.

Amendments of this decree in 2008 resulted in a minor change in the structure of the data collection. Until 2007 only the livestock numbers for six housing systems were collected, while since 2008 the amount of the manure has also been surveyed. In 2009 a more detailed livestock characterization was introduced for cattle and swine. At the same time sheep and goats were separated into two different categories.

The number of the received questionnaire has been increasing since 2003, although the representativeness of this sample varies between different years and livestock categories. The dataset is most representative for cattle and poultry, about 80-90 per cent of these

livestock are covered. It can be considered to be reliable for swine and sheep, too. About 50-60 per cent of the livestock is reported. It is least representative for goats and horse with 5-10 per cent coverage.

The Nitrogen Database contains more detailed housing systems for the period 2003-2011 than the previously used study (Ráki, 2003). Therefore the reported activity data for the period 1985-2002 were also revised to get a consistent time-series. New manure management systems reported in 'other category' were introduced, such as deep litter, poultry manure without bedding and yard. (Note: farmyard manure is only taken into account separately for swine, because for grazing animals it wasn't possible to distinguish between the proportion of 'pasture and paddock' and farmyard manure. In addition, the IPCC methodology does not provide emission factors and methane conversion factor for the farmyard manure.)

The applied data sources contain information on housing practices rather than manure management storage systems in many cases, therefore additional qualitative information was needed to define the relationship between the housing and manure management systems. Two studies (Mészáros, 2005 and Pazsiczky et. al, 2006) were applied to get additional information.

Despite the abovementioned methodological differences between the applied databases, the trend in the animal waste management systems distribution can be tracked.

The most significant change occurred in the poultry manure management in the last decade. From 2000 to 2010, the proportion of the liquid manure had dropped from 26 per cent to 3 per cent for laying hens. Previously, the semi-solid manure was diluted by water and handled as liquid manure, but recently the semi-solid manure is rather dried than diluted and handled as solid manure. Thus the liquid manure technology has been replaced by the drying technology as a result of environmental restrictions (Pazsiczky et. al, 2006). The other notable change in the poultry manure management is the decrease of the proportion of grazing for geese. As a result of the bird-flu scare, the animals are kept in stalls rather than pastures which increases the proportion of the liquid manure. (Goose is a waterfowl; therefore goose farming in a confined area needs large amount of technological water.)

For the other livestock category, a slight increase of the liquid manure (cattle and swine) and the extensive housing technology i.e. grazing (cattle, sheep, goats and horse) can be identified. The former may be explained by the increasing biogas production. The increasing proportion of grazing probably is the results of the high fodder prices.

The revised activity data for the base year and 2011 are presented in Table 6.3.3-6.3.6. The revised data for the year 2000 were used also for the base year and for the period 1985-1999 due to lack of information.

In line with an encouragement arising from the centralized review in 2013 the following actions were taken to increase livestock coverage during the survey of AWMS. The head of the Department of the Agri-environmental and Co-ordination of the NFCSO Directorate of Plant Protection and Agri-environment, who is assigned to the Nitrate Database, were contacted. According to the informations provided by the Office the numbers of the received questionnaires have been increasing gradually by annual 2000 pieces in the recent years. Besides, the former paper questionnaires are being replaced by on-line forms in 2014. Probably this measure will also improve the compliance with data provision obligations. Additionally, Hungary revised the area of the so-called 'Nitrogen Vulnerable Zones' (hereafter NVZs) in 2013. Thus, the areas designated as NVZs increased to approximately 68-69% of the country from the former 47%, further increasing the number of farms under the data provision obligations.

**Table 6.3.3** Animal waste management distribution for the base year per livestock categories

BY	Liquid	Solid	Pasture	Other
Dairy-Cattle	3.9%	43.6%	8.0%	44.5%
Young Cattle <1	3.6%	57.3%	11.5%	27.6%
Heifers 1-2 years	0.1%	37.0%	16.6%	46.3%
Cattle 1-2 years, male and Beef Cows >2 years	0.1%	30.9%	13.9%	55.1%
Swine	23.9%	25.3%	0.0%	50.8%
Laying hens	25.8%	48.8%	0.0%	25.5%
Cocks and broilers	0.0%	97.0%	0.0%	3.0%
Turkey	0.0%	100.0%	0.0%	0.0%
Geese	0.0%	81.8%	15.4%	2.8%
Ducks	0.3%	98.3%	0.0%	1.5%
Sheep	0.8%	60.3%	38.8%	0.0%
Goats	0.8%	59.2%	40.0%	0.0%
Horses	0.0%	83.8%	16.2%	0.0%

**Table 6.3.4** Animal waste management systems reported in 'Other' in the base year

BY	Deep litter	Yard	pit<1 month	pit>1 month	Poultry manure without bedding
Dairy-Cattle	44.5%	0.0%	0.0%	0.0%	0.0%
Young Cattle <1	27.6%	0.0%	0.0%	0.0%	0.0%
Heifers 1-2 years	46.3%	0.0%	0.0%	0.0%	0.0%
Cattle 1-2 years, male and Beef Cows > 2 years	55.1%	0.0%	0.0%	0.0%	0.0%
Swine	2.2%	0.8%	23.9%	23.9%	0.0%
Laying hens	0.0%	0.0%	0.0%	0.0%	25.5%
Cocks and broilers	0.0%	0.0%	0.0%	0.0%	3.0%
Geese	0.0%	0.0%	0.0%	0.0%	2.8%
Ducks	0.0%	0.0%	0.0%	0.0%	1.5%

**Table 6.3.5** Animal waste management distribution for the year 2012 year per livestock categories

2012	Liquid	Solid	Pasture	Other
Dairy-Cattle	4.2%	41.7%	10.2%	44.0%
Cattle<1	4.5%	51.6%	13.0%	30.8%
Heifers 1-2 years	1.0%	35.6%	17.0%	46.4%
Cattle 1-2 years, male and Non-dairy >2 years	4.9%	28.5%	20.3%	46.3%
Swine	24.1%	24.3%	0.0%	51.6%
Laying hens	18.8%	47.2%	0.0%	34.0%
Cocks and broilers	0.0%	97.7%	0.0%	2.3%
Turkey	0.0%	100.0%	0.0%	0.0%
Geese	1.2%	83.4%	12.4%	3.0%
Ducks	1.1%	97.0%	0.0%	1.9%

2012	Liquid	Solid	Pasture	Other
Sheep	0.6%	58.0%	41.4%	0.0%
Goats	0.6%	53.4%	46.0%	0.0%
Horses	0.0%	77.2%	22.8%	0.0%

**Table 6.3.6** Animal waste management systems reported in 'Other' in the year 2012

2012	Deep litter	Yard	pit<1 month	pit>1 month	Poultry manure without bedding
Dairy-Cattle	44.0%	0.0%	0.0%	0.0%	0.0%
Cattle<1	30.8%	0.0%	0.0%	0.0%	0.0%
Heifers 1-2 years	46.4%	0.0%	0.0%	0.0%	0.0%
Cattle 1-2 years, male and Non-dairy >2 years	46.3%	0.0%	0.0%	0.0%	0.0%
Swine	2.5%	0.9%	24.1%	24.1%	0.0%
Laying hens	0.0%	0.0%	0.0%	0.0%	34.0%
Cocks and broilers	0.0%	0.0%	0.0%	0.0%	2.3%
Geese	0.0%	0.0%	0.0%	0.0%	3.0%
Ducks	0.0%	0.0%	0.0%	0.0%	1.9%

**Activity data****Livestock Number**

Livestock population data provided by the HCSO are used for the estimation. For more details on the calculation of the annual average population and the activity data see section 6.2.2.1. The enhanced livestock characterization were used for the key categories according to the IPCC methodology. The livestock population data for swine by sub-categories are shown in Table 6.3.7.

**Table 6.3.7** Swine population and trends 1985-2012

Year	Swine Population 1,000 head						
	Piglets under 20 kg	Young pigs, 20-50 kg	Pigs for fattening over 50 kg	Breeding sows	Breeding boars	Guilt not yet mated	Sows mated for the first time
1985	2,017	1,761	4,394	23	685	78	92
BY	2,015	1,718	4,341	25	691	76	96
1986	2,020	1,727	4,268	25	684	76	103
1987	2,009	1,666	4,361	27	704	74	94
1988	1,986	2,465	3,535	27	681	109	85
1989	1,893	2,504	3,266	26	656	111	83
1990	1,953	2,626	3,240	27	658	116	89
1991	1,612	2,350	3,090	25	563	104	64
1992	1,310	1,844	2,436	20	487	82	58
1993	1,223	1,744	2,245	18	446	77	52
1994	1,050	1,499	1,958	15	373	66	45
1995	1,107	1,458	1,921	15	405	65	51
1996	1,257	1,524	2,147	16	430	67	53

Year	Swine Population 1,000 head						
	Piglets under 20 kg	Young pigs, 20-50 kg	Pigs for fattening over 50 kg	Breeding sows	Breeding boars	Guilt not yet mated	Sows mated for the first time
1997	1,188	1,302	2,040	14	356	57	56
1998	1,248	1,407	2,074	14	364	65	76
1999	1,282	1,503	2,300	15	397	56	57
2000	1,208	1,303	2,144	14	360	57	61
2001	1,261	1,108	1,985	13	342	55	61
2002	1,361	1,137	2,043	13	368	60	68
2003	1,282	1,158	2,151	12	362	56	57
2004	1,064	1,015	1,885	10	309	50	51
2005	999	917	1,702	10	292	51	53
2006	976	933	1,636	9	282	55	54
2007	1,015	934	1,700	8	279	52	50
2008	878	848	1,595	7	250	46	41
2009	758	796	1,374	6	227	45	44
2010	764	752	1,374	7	225	42	45
2011	750	745	1,321	6	217	43	38
2012	703	721	1,238	5	205	42	38
Trend BY-2012	-65%	-58%	-71%	-81%	-70%	-45%	-61%

**Annual average Nitrogen excretion rates ( $N_{ex}$ )** – country specific parameters were used for Dairy Cattle, Non-Dairy Cattle and Swine, based on the new research conducted on behalf of the HMS by the University of Gödöllő in 2013 (Kovács, 2013). In case of cattle the Nitrogen excretion rates were developed consistently with the nitrogen content of the feed as it was determined in conjunction with the examination of gross energy intake (see also section 6.2.2.2). For Swine the N-excretion rates were also determined based on the nitrogen content of the feed intake. The amounts of the protein containing feed ingredients in the diet were determined for the whole time-series from the available statistics, Hungarian standards and supplemented with expert judgment.

To get the new, more reliable results the N excretion rates were generally calculated using the Equation 4.19 of the GPG (IPCC, 2000). The Nitrogen intakes were determined from the crude protein content of each feed ingredient in the diet for all sub-categories of these animal species. Data on crude protein content were taken from the so-called 'feed database' containing the laboratory measurements of all kind of feed used for animal nutrition in Hungary. The feed database is available in the Hungarian Nutrition Codex, 2004. The N-intakes were calculated multiplying the crude protein intakes by 0.16, because proteins typically contain 16% Nitrogen. The values of fraction of annual N-intakes that is retained by animals and their sources are summarized in Table 6.3.8. The resulted values of N-excretion for Dairy-Cattle and non-Dairy-Cattle are provided in Table 6.2.5 and 6.2.8, respectively, while values of N excretion for Swine are presented in Table 6.3.9.

**Table 6.3.8**  $N_{\text{retention}}$  rates and their sources

Animal species	$N_{\text{retention}}$	Source
Dairy Cattle	0.20	GPG (IPCC, 2000)
Non-Dairy Cattle	0.07	GPG (IPCC, 2000)
Swine	0.37	weighted average (2012)
Piglets under 20 kg	0.48	Fébel and Gundel, 2007
Young pigs, 20-50 kg	0.34	Fébel and Gundel, 2007
Pigs for fattening over 50 kg	0.34	Fébel and Gundel, 2007
Breeding sows	0.30	GPG (IPCC, 2000)
Breeding boars	0.30	GPG (IPCC, 2000)
Guilts not yet mated	0.34	Fébel and Gundel, 2007
Sows mated for the first time	0.34	Fébel and Gundel, 2007

In the case of the other livestock categories the default values from Table 4-20, on p. 4.99 in the Revised Guidelines 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 (Table 6.3.10).

**Table 6.3.9** Annual average Nitrogen excretion rates ( $N_{\text{ex}}$ ) for Swine

Sub-categories	Body weight	$N_{\text{ex}}$
	kg	[kg head <sup>-1</sup> year <sup>-1</sup> ]
Piglets under 20 kg	12	3.0
Young pigs, 20-50 kg	34	8.6
Pigs for fattening over 50 kg	90	12.5
Breeding sows	180	18.5
Breeding boars (BY)	209	21.1
Breeding boars (2012)	180	19.4
Guilts not yet mated	87	9.9
Sows mated for the first time	150	13.8
<b>Swine, weighted average (BY)</b>	<b>69.5</b>	<b>10.1</b>
<b>Swine, weighted average (2012)</b>	<b>64.9</b>	<b>9.6</b>

**Table 6.3.10** Annual average Nitrogen excretion rates ( $N_{\text{ex}}$ ) for Buffalo, Sheep, Goats, Horses, Asses and Mules and Poultry

Animal Category	$N_{\text{ex}}$ [kg head <sup>-1</sup> year <sup>-1</sup> ]	Sources
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.

### 6.3.2.2 Emission factors

#### 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>]

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]

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

#### Volatile solid excretion per day (VS)

Country-specific values of VS for Cattle, Laying hens and Broilers were calculated according to the Equation 4.16 of GPG (IPCC, 2000).

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

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 estimation of gross energy intake and digestible energy of feed for Cattle are detailed in Chapter 6.2.2.2.

Metabolisable and digestible energy of feed for Laying hens and Broilers were calculated similarly, based on the feeding practices. Forage composition parameters were also taken from the Hungarian Nutrition Codex.

For the ash content of the manure the IPCC default value (8%) was applied due to lack of country-specific values.

The time-series of volatile solid excretion rates and CH<sub>4</sub>-emission factors for Manure Management for Dairy Cattle are shown in Table 6.3.11.

**Table 6.3.11** Volatile solid excretion rates and CH<sub>4</sub>-emission factors for Manure Management for Dairy Cattle 1985-2012

Year	VS excretion	CH <sub>4</sub> -Emission Factor
	kg DM/day	kg/head*yr
1985	3.97	45.23
BY	3.98	45.35
1986	4.00	45.53
1987	3.98	45.30

Year	VS excretion	CH <sub>4</sub> -Emission Factor
	kg DM/day	kg/head*yr
1988	4.00	45.58
1989	3.93	44.78
1990	3.91	44.48
1991	3.77	42.94
1992	3.75	42.71
1993	3.72	42.40
1994	3.71	42.19
1995	3.71	42.29
1996	3.74	42.54
1997	3.75	42.65
1998	3.82	43.46
1999	3.83	43.60
2000	3.88	44.17
2001	3.92	44.57
2002	3.96	44.95
2003	3.96	44.88
2004	3.95	44.74
2005	3.98	44.98
2006	4.08	46.03
2007	4.16	46.85
2008	4.25	47.76
2009	4.25	47.70
2010	4.27	47.83
2011	4.42	49.51
2012	4.49	50.29

Table 6.3.12 and 6.3.13 contain parameters (GE, DE, ASH) used for the calculations of volatile solid excretion rate for non-dairy cattle for the BY and for 2012.

**Table 6.3.12** Volatile solid excretion rate and CH<sub>4</sub>-Emission Factor for Non-Dairy Cattle in the BY

BY		<1 year		1-2 year		>2 year			
		Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
Digestible Energy	%	69	71	62	62	69	66	67	69
Gross Energy Intake	MJ/head*day	94	92	156	160	200	192	185	157
ASH	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
VS excretion	kg DM/day	1.5	1.3	2.9	3.0	3.0	3.2	3.1	2.5
CH <sub>4</sub> -Emission Factor	kg/head*yr	11	10	32	33	39	42	40	32

**Table 6.3.13** Volatile solid excretion rate and CH<sub>4</sub>-Emission Factor for Non-Dairy Cattle in 2012

2012		<1 year		1-2 year		>2 year			
		Bovines for slaughter and other calves (male)	Bovines for slaughter and other calves (female)	Bovines (male)	Heifers for slaughter and other heifers	First calf heifers	Mature Non-Dairy (male)	Heifers for slaughter	Beef Cow
Digestible Energy	%	69	70	61	62	68	65	65	67
Gross Energy Intake	MJ/head*day	94	94	161	163	192	199	191	162
ASH	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
VS excretion	kg DM/day	1.5	1.4	3.1	3.1	3.1	3.5	3.3	2.7
CH <sub>4</sub> -Emission Factor	kg/head*yr	16	15	37	36	31	35	33	26

For the other livestock categories the IPCC default values provided by the Table B-2 and B-7 in the Rev. Guidelines (IPCC, 1996) were used except for poultry. In the case of poultry neither the Rev. Guidelines (IPCC, 1996) nor the GPG (IPCC, 2000) provide default values, therefore Table 10A.9 of the Guidelines (IPCC, 2006) were used. IPCC default values for geese and guinea fowls are not available; hence values for ducks and broilers were used, respectively.

#### Maximum CH<sub>4</sub> producing capacity (B<sub>0</sub>) values

Due to lack of country specific data the default values listed in Appendix B-4 of the Rev. Guidelines (IPCC, 1996) were applied.

#### CH<sub>4</sub> conversion factors (MCF)

The IPCC default values Table 4.10 of GPG (IPCC, 2000) were used.

#### Ash content

The IPCC default value (8%) was used (GPG 2000, 4.31. p.).

#### Methane conversion factors

IPCC default factors provided in Table 4.10 and 4.11 of GPG (IPCC, 2003) were applied. The GPG (IPCC, 2003) provides no methane conversion factor for Yard, therefore the MCF of Pasture range and paddock was applied.

**Table 6.3.14** Methane conversion factors for manure management systems

Manure Management System	MCF [%]
Pasture range and paddock	1
Solid storage and dry lot	1
Liquid system	39
Other AWMS	
Pit storage <1 month	0
Pit storage >1 month	39
Cattle and Swine Deep Litter	39
Yard	1
Poultry manure without bedding	1.5

Source: GPG (IPCC, 2000) Table 4.10 and 4.11

### Emission factors for N<sub>2</sub>O

The IPCC default emission factors were used. In the GPG (IPCC, 2003) no emission factor is available for Yard, therefore the emission factor for solid manure was applied.

**Table 6.3.15** Emission factors used for the estimation of the N<sub>2</sub>O emissions

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	0.020
Solid storage	0.020
Liquid system	0.001
Other AWMS	
Pit storage <1 month	0.001
Pit storage >1 month	0.001
Cattle and Swine Deep Litter	0.020
Yard	0.020
Poultry manure without bedding	0.005

Source: GPG2000, Table 4-12 and Table 4.13

## 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 6.1.3.)

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 ±19 % 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 49% and the upper one is 84%.

## 6.3.4 Source specific QA/QC

The new research results on N-excretion rate for Cattle and Swine were verified using different calculation methodologies and compared with values used by other countries.

For Dairy-Cattle two different methodologies were used for the verification of N-excretion values. Firstly, the N-excretion was estimated based on the body mass and milk yields according to the methodology provided in Febel and Gundel, 2007. This methodology indicates a value of 114.5 kg N/head/year for the year 2012, which is higher than the value applied in the inventory. In comparison, the methodology suggested by the Guidelines (IPCC, 2006) resulted in a significantly lower value of 89.6 kg N/head/year for the year 2012.

According to the Guidelines data on the protein content of the milk was also taken into account in this calculation. As a consequence, the 100.4 kg N/head/year, which was applied in the inventory, is in the range of the values resulted by the other methodologies.

In case of Non-Dairy Cattle and Swine the methodology provided in Febel and Gundel, 2007 indicates lower values, although for Swine the difference is insignificant. Comparing the new N-excretion values with the values used by the other EU's member state countries the Hungarian values were in the range of the EU's values.

### 6.3.5 Source-specific recalculations

For the 2014 submission the following recalculations were done.

#### 4.B Manure Management CH<sub>4</sub>

- Revision of volatile solid excretion rate for Cattle and Poultry for the full time-series
- Revision of Poultry livestock population for the year 2011

#### 4.B Manure Management N<sub>2</sub>O

- Revision of N excretion rate of Cattle and Swine for the full time-series
- Revision of Poultry livestock population for the year 2011

The overall impact of the recalculations on the total GHG emissions from 4.B Manure Management is a decrease of 1% in 2011 and 5% in the BY. This decrease is mainly the effect of the slightly lower level of CH<sub>4</sub> emissions due to the recalculation of the GE for Cattle. The overall decrease in the emissions of N<sub>2</sub>O is lower than the CH<sub>4</sub>, because the effect of the lower N-excretion rates for Cattle was partly counterbalanced by the effect of the slightly higher N-excretion rates for Swine.

**Table 6.3.16** Changes in CH<sub>4</sub> emissions from 4.B Manure Management due to recalculations

Year	Submission 2013 [Gg CH <sub>4</sub> ]	Submission 2014 [Gg CH <sub>4</sub> ]	Difference [Gg CH <sub>4</sub> ]	Percentage change
BY	170	159	-11	-6.3%
1985	173	162	-11	-6.4%
1986	168	158	-11	-6.3%
1987	167	157	-10	-6.3%
1988	166	155	-10	-6.2%
1989	160	150	-10	-6.4%
1990	159	150	-10	-6.0%
1991	146	136	-10	-6.6%
1992	120	112	-8	-6.7%
1993	108	101	-7	-6.6%
1994	94	88	-6	-6.7%
1995	93	87	-6	-6.3%
1996	98	92	-6	-5.8%
1997	92	87	-5	-5.5%
1998	93	88	-5	-5.4%
1999	97	92	-5	-5.0%
2000	91	86	-5	-5.1%
2001	86	82	-4	-5.1%
2002	88	84	-4	-4.8%
2003	88	84	-4	-4.8%
2004	79	75	-4	-5.1%
2005	75	71	-4	-5.1%
2006	73	69	-3	-4.7%
2007	74	71	-3	-4.3%
2008	69	67	-3	-4.1%

Year	Submission 2013 [Gg CH <sub>4</sub> ]	Submission 2014 [Gg CH <sub>4</sub> ]	Difference [Gg CH <sub>4</sub> ]	Percentage change
2009	64	62	-3	-4.2%
2010	64	61	-3	-4.0%
2011	62	60	-2	-3.3%

**Table 6.3.17** *Changes in N<sub>2</sub>O emissions from 4.B Manure Management due to recalculations*

Year	Submission 2013 [Gg N <sub>2</sub> O]	Submission 2014 [Gg N <sub>2</sub> O]	Difference [Gg N <sub>2</sub> O]	Percentage change
BY	6.4	6.3	-0.1	-1.6%
1985	6.5	6.4	-0.1	-1.9%
1986	6.4	6.3	-0.1	-1.6%
1987	6.3	6.2	-0.1	-1.3%
1988	6.1	6.0	-0.1	-1.0%
1989	5.9	5.8	0.0	-0.2%
1990	5.6	5.7	0.0	0.3%
1991	5.2	5.2	0.0	0.4%
1992	4.6	4.6	0.0	0.1%
1993	3.9	3.9	0.0	-0.2%
1994	3.6	3.5	0.0	-0.5%
1995	3.5	3.5	0.0	1.2%
1996	3.3	3.3	0.1	1.8%
1997	3.2	3.3	0.1	2.8%
1998	3.3	3.4	0.1	3.1%
1999	3.3	3.4	0.1	3.0%
2000	3.4	3.5	0.1	2.7%
2001	3.4	3.4	0.1	2.5%
2002	3.3	3.4	0.1	2.7%
2003	3.3	3.4	0.1	2.8%
2004	3.2	3.3	0.1	2.5%
2005	3.1	3.2	0.1	3.3%
2006	2.9	3.0	0.1	3.9%
2007	2.9	3.0	0.1	4.0%
2008	2.8	2.9	0.1	3.1%
2009	2.7	2.8	0.1	3.2%
2010	2.7	2.8	0.1	3.0%
2011	2.7	2.7	0.1	2.0%

### 6.3.6 Planned improvements

The main goal is the introduction of the methodologies provided in the IPCC 2006 Guidelines in the reporting for the 2015 submission.

Data and surrogate data collection on biogas production and bio digesters using animal manure is in progress. As it was mentioned in section 6.1.7, the installation of the new biogas plants resulted in additional changes in the manure management, thus the AWMS data are to be revised for the years 2011 and 2012.

## 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. Following a potential recommendation arising from the centralized review in 2013 the incorrect notation key was replaced by 'NO' in CRF Table 4.C in line with this information.

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 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: 4.D.1 Direct: Level 1, 2; Trend 1, 2;  
4.D.2 Indirect: Level 1, 2; Trend 1, 2;

In 2012 agricultural soils emitted 86% of the total N<sub>2</sub>O emissions of the agriculture sector, and 75% of the national total N<sub>2</sub>O emissions are generated in agricultural soils. Emissions from the agricultural soils contributed 8.2 percent (5,087 Gg CO<sub>2</sub>-eq) to the Hungarian total GHG emissions in 2012. (See Table 6.1.2)

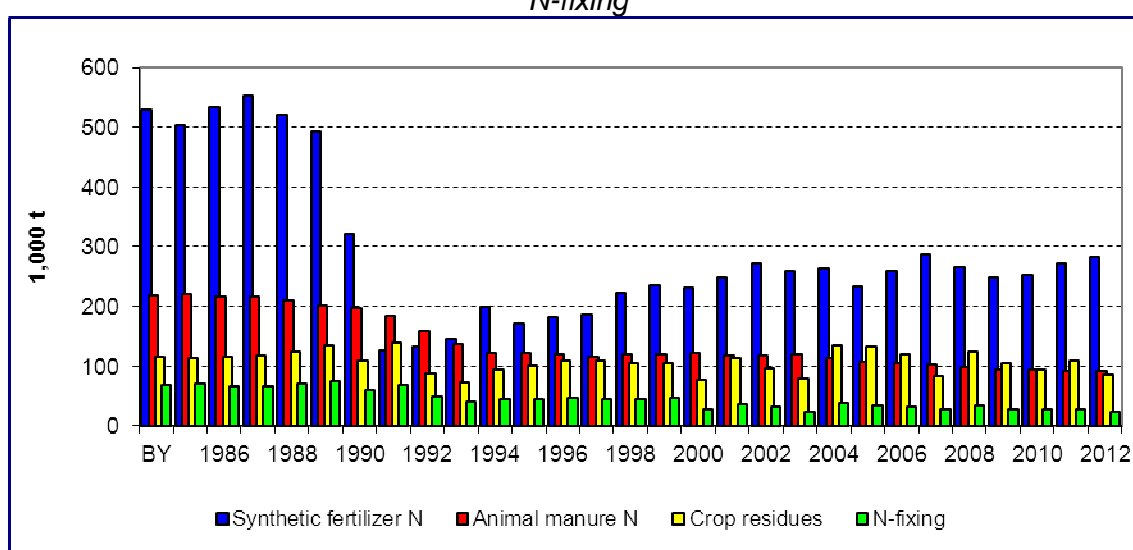
The overall trend in emissions is decreasing. The emissions from Agricultural soils have reduced to 48 per cent of the 1985-1987 levels in 2012. A significant drop had occurred in the period 1985-1993 due to the significant decrease in livestock population and synthetic fertilizer use which resulted in less N-input (Figure 6.5.1). After reaching the lowest point of the emissions level in 1993 there was a slight increase until 1998 due to a small rise in synthetic fertilizer use. After that emissions levels remained quasi stable in the period 1998-2012 as a result of compensatory processes between the different sources of N amendment. 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 6.5.1.

**Table 6.5.1 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
BY	18.29	10.40	4.28	1.33	2.27	0.99	1.88	10.52
1985	17.81	9.87	4.34	1.38	2.22	1.03	1.85	10.22
1986	18.31	10.49	4.26	1.31	2.25	0.98	1.88	10.55
1987	18.74	10.85	4.26	1.31	2.33	0.97	1.91	10.79
1988	18.15	10.23	4.11	1.38	2.43	0.93	1.82	10.25
1989	17.77	9.68	3.97	1.48	2.64	0.90	1.74	9.77
1990	13.54	6.33	3.88	1.18	2.14	0.83	1.42	7.45
1991	10.13	2.48	3.60	1.35	2.71	0.83	1.02	4.66
1992	8.39	2.62	3.09	0.96	1.72	0.75	0.93	4.34
1993	7.73	2.85	2.68	0.78	1.42	0.61	0.85	4.14
1994	9.06	3.92	2.40	0.88	1.85	0.50	0.88	4.61
1995	8.62	3.38	2.38	0.89	1.97	0.48	0.82	4.22
1996	8.97	3.59	2.35	0.92	2.12	0.46	0.83	4.33
1997	8.94	3.64	2.27	0.87	2.16	0.45	0.82	4.30
1998	9.68	4.38	2.33	0.89	2.08	0.47	0.90	4.85
1999	9.97	4.63	2.37	0.92	2.05	0.47	0.93	5.04
2000	9.02	4.56	2.39	0.54	1.52	0.53	0.94	5.03
2001	10.10	4.86	2.31	0.69	2.24	0.53	0.95	5.17
2002	10.15	5.36	2.32	0.60	1.88	0.54	0.99	5.51
2003	9.47	5.11	2.33	0.47	1.56	0.58	0.98	5.37
2004	10.77	5.18	2.20	0.75	2.64	0.64	0.97	5.35
2005	9.96	4.60	2.11	0.67	2.59	0.68	0.90	4.90
2006	10.13	5.11	2.04	0.63	2.35	0.68	0.93	5.19
2007	9.83	5.66	2.01	0.52	1.64	0.68	0.97	5.53
2008	10.23	5.20	1.93	0.67	2.42	0.69	0.92	5.17
2009	9.30	4.86	1.85	0.55	2.04	0.71	0.87	4.89
2010	9.20	4.97	1.84	0.55	1.84	0.73	0.88	4.96
2011	9.81	5.34	1.80	0.54	2.13	0.71	0.91	5.17
2012	9.45	5.53	1.79	0.46	1.68	0.73	0.92	5.30

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
Share in Hungarian total N <sub>2</sub> O emissions in BY	33%	19%	8%	2%	4%	2%	3%	19%
Share in Hungarian total N <sub>2</sub> O, in 2012	43%	25%	8%	2%	8%	3%	4%	24%
Trend BY-2012	-48%	-47%	-58%	-66%	-26%	-26%	-51%	-50%

**Figure 6.5.1** Trends from N-inputs from synthetic fertilizer, animal manure, crop residues and N-fixing



### 6.5.2 Methodological issues

Estimations were carried out on the basis of the GPG (IPCC, 2000) using the Tier 1a and Tier 1b methodologies with default emission factors depending on the availability of the required data. Values of emission factors used for the calculation of N<sub>2</sub>O emissions from Agricultural Soils are summarized in Table 6.5.2.

**Table 6.5.2** Values of emission factors used for the calculation of N<sub>2</sub>O emissions from Agricultural Soils

Category	Emission Factor	Source
4.D.1 Direct Soils Emission		
4.D.1.1 Syntehetic Fertilizers	0.0125  kg N <sub>2</sub> O-N/kg N	Table 4.17 GPG(IPCC, 2003)
4.D.1.2 Animal Manure Applied to Soils		
4.D.1.3 N-fixing Crops		
4.D.1.4 Crop residue		
4.D.2 Pasture, Range and Paddock manure		
Pasture/ range/ paddock	0.02 kg N <sub>2</sub> O-N/kg N	Table 4.12 GPG(IPCC, 2003)
4.D.3 Indirect soils		
4.D.3.1 Atmospheric Deposition	0.01 kg N <sub>2</sub> O-N/kg N deposited	Table 4.18 GPG(IPCC, 2003)
4.D.3.2 Nitrogen Leaching and run-off	0.025 kg N <sub>2</sub> O-N/kg N leached and run-off	Table 4.18 GPG(IPCC, 2003)

### 6.5.2.1 Activity Data

The required activity data such as amount of synthetic N-fertilizer used (Table 6.5.4), total harvested production of legumes and other crops were taken from the HCSO's statistics whereas amount of animal manure nitrogen applied to soils was estimated based on the HCSO's livestock statistics. The summary of the activity data and their sources are provided in Table 6.5.3.

**Table 6.5.3** Sources of activity data for 4.D

Category	Activity Data	Source
<b>4.D.1 Direct Soils Emission</b>		
4.D.1.1 Synthetic Fertilizers	Synthetic fertilizer used	Quantity of sold fertilizer, HCSO (1985-2012)
4.D.1.2 Animal Manure Applied to Soils	Animal manure nitrogen produced annually	Calculated in 4.B
4.D.1.3 N-fixing Crops	Harvested amount of Nitrogen-fixing crops	Harvested production statistics for Legumes, HCSO, 1985-2012
4.D.1.4 Crop residue	Harvested amount of crops	Harvested production statistics, HCSO, 1985-2012

4.D.2 Pasture, Range and Paddock manure		
4.D.2 Pasture/ range/ paddock	Animal manure nitrogen produced by grazing animals	Calculated in 4.B
4.D.3 Indirect soils		
4.D.3.1 Atmospheric Deposition	Sold Synthetic fertilizer;	Quantity of sold fertilizer, HCSO (1985-2012);
4.D.3.2 Nitrogen Leaching and run-off	Animal manure nitrogen produced annually	Calculated in 4.B

### *Synthetic Fertilizer use*

The fertilizer consumption data in the GHG inventory derives from the HCSO's statistics on the quantity of sold fertilizer. Collection of this data is executed according to the Hungarian Statistical Data Collection Programme by the Research Institute on the Agricultural Economics. Although, this is a sales statistics instead of consumption data, but so comprehensive survey on fertilizer consumption there is not available in Hungary. Moreover, this sale statistics contains the sold fertilizers by product line, which enables us to determine the amount of Nitrogen applied to soils by fertilizer types, thus the detailed and more accurate calculation of volatilization and indirect emissions in the near future.

The activity data as 'synthetic fertiliser use for the period 1985-2012 are provided in Table 6.5.4.

**Table 6.5.4** *Synthetic fertilizer and Animal Manure N use (1985-2012)*

Year	Synthetic Fertilizer N applied (kt N/year)	Animal Manure N (kt N/year)
1985	558	309
BY	589	304
1986	593	302
1987	614	302
1988	579	291
1989	548	281
1990	358	274
1991	140	255
1992	148	221
1993	161	190
1994	222	169
1995	191	167
1996	203	164
1997	206	159
1998	248	163
1999	262	166
2000	258	169
2001	275	164
2002	303	165

Year	Synthetic Fertilizer N applied (kt N/year)	Animal Manure N (kt N/year)
2003	289	167
2004	293	161
2005	260	156
2006	289	151
2007	320	150
2008	294	145
2009	275	140
2010	281	140
2011	302	137
2012	313	137
Trend BY-2012	<b>-47%</b>	<b>-55%</b>

#### *Animal manure use*

Data on animal manure use were calculated in the sector 4.B based on the livestock population and the annual N-excretion data by animal species. For more details see section 6.3.2.

#### *Harvested Production Statistics*

Data on harvested amount of crops used for the calculation of emissions from 4.D.1.3 and 4.D.1.4 were provided by the HCSO.

### 6.5.2.2 Direct soil (CRF sector 4.D.1)

Direct soil emissions are the main source of  $N_2O$  in the Hungarian inventory. In 2012, 43% of the total  $N_2O$  emissions originated from this sector (Table 6.5.1), which includes the synthetic N-fertilizer and animal manure use, the cultivation of N-fixing crops and the effects of crop residues.

Following a recommendation from the centralized review in 2013, a more detailed methodological description of this sector was added to the Chapter of 4.D for this submission.

Emissions from these sources were calculated using the Tier 1a methodology based on the Equation 4.20 of GPG (IPCC, 2000). The  $N_2O$ -N was converted to  $N_2O$  by the factor (44/28) in line with the IPCC methodology.

Terms of the Equation 4.20 were determined using the following equations of the GPG (IPCC, 2000):

- $F_{SN}$ , N from synthetic fertilizer application, Equation 4.22;
- $F_{AM}$ , N from animal manure application, Equation 4.23;
- $F_{BN}$ , N fixed by crops, Tier 1b, Equation 4.26 and 4.27;
- $F_{CR}$ , N in crop residue returned to soils, Tier 1b, Equation 4.29.

#### *N input from synthetic fertilizer use ( $F_{SN}$ )*

The total amount of synthetic fertilizer nitrogen applied to soils was adjusted for the amount that volatilizes as  $NH_3$  and  $NO_x$  for the calculation of  $F_{SN}$ . The fraction of nitrogen loss by volatilization ( $Frac_{GASF}$ ) was determined using the IPCC default value of 10% provided in the Table 4-19 of Rev. Guidelines (IPCC, 1996).

#### *N input from animal manure application ( $F_{AM}$ )*

The N input from animal manure application was estimated from the total annual amount of the N-excreted, which had been calculated for the 4.B sector. This value was adjusted for the volatilization, using the IPCC default value of 20% provided in the Table 4-19 of Rev. Guidelines (IPCC, 1996). The fraction of manure deposited onto the soils by grazing animals ( $Frac_{PRP}$ ) was also taken into account according to the Equation 4.23. The value of animal manure burning for fuel ( $Frac_{FUEL-AM}$ ) can be assumed as zero. The use of animal manure for animal feed or construction is not relevant to Hungary. Therefore the use of the expanded equation is not reasonable.

#### *N input from N-fixing crops*

The N input from the N-fixed by legumes was calculated using the Tier 1b methodology. Parameters used as inputs for the calculation are listed in Table 6.5.6. Values provided in the Table 4.16 of the GPG (IPCC, 2003) are used for the Residue/Crop Product Ratio, Dry matter fraction and Fraction of N in DM, generally. However, in the case of Lucerne hay/seed and Red clover hay, when the residue is used as fodder, country specific values are applied taken from the Hungarian Nutrition Codex (2004), containing laboratory measurements data for fodder crops. While in other cases, when either default values or country specific values were not available, default values provided for similar crops were applied as it is indicated in Table 6.5.6.

*N input from crop residues*

N input from crop residues were calculated following the IPCC Tier 1b methodology. The fraction of residue burned in the field before and after harvest ( $Frac_{BURN}$ ) were assumed to be zero, because the on-site burning of crop residues is prohibited in accordance with the Hungarian air quality law (see also Chapter 6.7). The use of crop residues for construction, fodder and burned as fuel is assumed to be negligible, therefore these fractions ( $Frac_{CNST-CR}$ ,  $Frac_{FOD}$ ,  $Frac_{BURN}$ ) are considered to be zero as a conservative approach.

Values listed in Table 6.5.5 were applied as further inputs of the calculation using the Equation 4.29. Generally, the IPCC default values provided in the Table 4.16 of the GPG (IPCC, 2003) were used for the Residue/Crop Product Ratio, Dry matter fraction and Fraction of N in DM. However, in that cases when the crop residues could be used as fodder, country specific values taken from the Hungarian Nutrition Codex (2004) were applied. For both oilseed rape and sunflower seed country-specific values were applied taken from the research study of Zsembeli et. al. (2011). Being the major oilseeds in Hungary, the cropping area of them has been increasing gradually in the last decades, because of the growing demand for biofuels, resulting in an increasing importance in the inventory.

Following a potential recommendation arising from the centralized review in 2013 the country-specific data to estimate  $N_2O$  emissions from crop residues for sunflower and oilseed rape are now provided in the Table 6.5.5. together with the sources of these values.

For other crops for which either default values or country specific values were not available, default values provided for similar crops were applied as it is provided in Table 6.5.5.

**Table 6.5.5** Parameters used to estimate emissions from N-fixing and crop residues

Crops	Residue/ Crop Product Ratio	Dry matter fraction	Fraction of N in DM	Source
Wheat	1.3	0.850	0.0028	GPG (IPCC, 2000)
Meslin	1.3	0.850	0.0028	GPG (IPCC, 2000) as wheat
Maize	1.0	0.780	0.0081	GPG (IPCC, 2000)
Rice	1.4	0.850	0.0067	GPG (IPCC, 2000)
Barley	1.2	0.850	0.0043	GPG (IPCC, 2000)
Rye	1.6	0.900	0.0048	GPG (IPCC, 2000)
Oats	1.3	0.920	0.0070	GPG (IPCC, 2000)
Triticale	1.3	0.850	0.0028	GPG (IPCC, 2000) as wheat
Other cereals	1.3	0.850	0.0028	GPG (IPCC, 2000) as wheat
Potatoes	0.4	0.22	0.0110	GPG (IPCC, 2000); dry matter fraction from Table 11.2 of GL(IPCC, 2006)
Beans	2.1	0.855	0.0230	GPG (IPCC, 2000), N-Fraction as Soybeans
Peas	1.5	0.870	0.0142	GPG (IPCC, 2000)
Lentil	2.1	0.855	0.0230	GPG (IPCC, 2000), Residue/Crop Product Ratio and Dry matter fraction as Beans, N-Fraction as Soybeans
Broad bean	2.1	0.855	0.0230	GPG (IPCC, 2000), Residue/Crop Product Ratio and Dry matter fraction as Beans, N-Fraction as Soybeans
Lupin	2.1	0.855	0.0230	GPG (IPCC, 2000), Residue/Crop Product Ratio and Dry matter fraction as Beans, N-Fraction as Soybeans

Crops	Residue/ Crop Product Ratio	Dry matter fraction	Fraction of N in DM	Source
Soyabean	2.1	0.865	0.0230	GPG (IPCC, 2000)
Sunflower seed	3.0	0.800	0.0057	Country-specific, Zsembeli et al, 2011
Rape seed	2.0	0.700	0.0033	Country-specific, Zsembeli et al, 2011
Linseed	1.2	0.855	0.0230	Residue/Crop Product Ratio, Antal (2005); Dry matter Fraction as Bean, N-fraction as Soybean
Poppy seed	2.2	0.860	0.0150	Residue/Crop Product Ratio and Dry matter Fraction Antal (2005); N-fraction default value provided by Rev. GL(IPCC, 1996)
Sugar-beet	0.3	0.940	0.0228	Residue/Crop Product Ratio and N-Fraction from GPG(IPCC, 2000) as Feedbeet, Dry matter fraction from Table 11.2 of GL(IPCC, 2006) as Root crops
Lucerne seed	6.7	0.860	0.0160	Residue/Crop Product Ratio, Antal (2005). Dry matter fraction and Fraction of N in DM Hungarian Nutrition Codex, 2004
Seeds of grass	8.0	0.860	0.0083	Residue/Crop Product Ratio from HCSO, Dry matter Fraction and N-fraction from Hungarian Nutrition Codex, 2004
Lucerne hay	0.0	0.864	0.0333	Country-specific, Hungarian Nutrition Codex, 2004
Red clover hay	0.0	0.855	0.0274	Country-specific, Hungarian Nutrition Codex, 2004
Tomatoes	0.4	0.220	0.0110	as Potatoes
Cucumber	0.4	0.220	0.0110	as Potatoes
Watermelon	0.4	0.220	0.0110	as Potatoes
Melon	0.4	0.220	0.0110	as Potatoes
Green peas (grain weight)	1.5	0.870	0.0142	GPG (IPCC, 2000), as Peas
Green beans	2.1	0.855	0.0230	GPG (IPCC, 2000), Residue/Crop Product Ratio and Dry matter fraction as Beans, N-Fraction as Soybeans
Sweet pepper	0.4	0.220	0.0110	as Potatoes
Bonnet pepper	0.4	0.220	0.0110	as Potatoes
Sweet corn	1.0	0.780	0.0081	GPG (IPCC, 2000) as Maize
Hungarian red paprika	0.4	0.220	0.0110	as Potatoes

#### *Cultivation of Histosols*

Cultivation of Histosols is not occurring in Hungary, therefore notation key 'NO' is reported for the N<sub>2</sub>O emission.

As a result of identification a potential problem raised by the ERT during the 2013 annual review, the NIR has been supplemented with the following justification.

In the Hungarian soil classification system 'Peat soils' and 'Ameliorated peat soils' could be identified as WRB Histosols. Peat soils form and can be restored under wetland conditions, which are 'ex lege' protected in Hungary in accordance with the art. 23. of Act LIII of 1996.

(This law is in force currently, but Wetlands was protected decades ago.) Hungary also signed the Ramsar convention in 1971, thus the protection of wetlands are also encouraged based on this convention. As a consequence, areas of wetland soils are mainly national parks and landscape protection areas.

Before the 1950's attempts were made on the utilization of peat lands, by draining. The results of this activity are the 'Ameliorated peat soils'. After draining, the organic carbon content of these soils declined resulting from the oxidization of organic matters during a more than 60 years of continuous cultivation. Consequently, as it is proved by measurements, these cultivated 'Ameliorated peat soils' have an average humus content of 6%, which do not meet the definition of 'Histosols' or 'organic soils' used in the IPCC guidelines.

The data of the Hungarian Soil monitoring system prove this fact, namely there are no croplands on organic soil in Hungary. The LUCAS Topsoil Data (EU JRC, 2013) providing measured organic carbon data for 20,000 sample points in Europe for the year 2009 were also analyzed and confirmed that organic soils are not cultivated in Hungary.

As a consequence of the facts due to the domestic legislation on one hand and based on research results on the other, it can be confirmed that organic soils are not cultivated in Hungary. Soils in Hungary, which are classified as Histosols in international soil databases (eg. FAO HWSD) are either on protected wetlands (peat soils) or, if on managed croplands and grasslands, they have lost most of their carbon content (ameliorated peat soils).

#### **6.5.2.3 Pasture Range and Paddock manure (4.D.2)**

Emissions from Pasture Range and Paddock manure was calculated in line with other animal waste management system but is reported under CRF sector 4.D.2, according to the IPCC methodology. Thus the Equation 4.18 was used for the estimation and the emission factor was taken from the Table 4.12 of the GPG (IPCC, 2000). The amount of the Nitrogen excreted during grazing was calculated from the values provided in Table 6.2.5, 6.2.8 in section 6.2.2.2 and Table 6.3.9, Table 6.3.10 in section 6.3.2.

#### **6.5.2.4 Indirect Emissions (CRF 4.D.3)**

N<sub>2</sub>O emissions from atmospheric deposition and leaching of nitrogen are reported under CRF sector 4.D.3 following the Equation 4.30.

##### *Atmospheric deposition*

The N<sub>2</sub>O emissions from atmospheric deposition of Nitrogen are calculated based on the Tier 1a methodology, following the Equation 4.31. The activity data are the same as those under 4.D.1. The emission factor was taken from Table 4.18 of GPG (IPCC, 2000).

##### *Leaching and runoff*

The N<sub>2</sub>O emissions from the deposited Nitrogen from leaching and runoff are calculated using the Equation 4.34. The activity data are the same as those under 4.D.1. The value of  $Frac_{LEACH}$  were taken from the Table 4-24 of Rev. Guidelines (IPCC, 1996) and the Table 4.18 of GPG (IPCC, 2000), respectively.

### 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  $F_{\text{SN}}$  is 50%. A combined uncertainty of  $\pm 79\%$  can be estimated for  $F_{\text{AM}}$ . (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  $F_{\text{BN}}$  resulted in  $\pm 40\%$ , while the uncertainty of the  $F_{\text{CR}}$   $\pm 25\%$  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

Indirect emissions from atmospheric deposition onto agricultural soils ( $\text{Frac}_{\text{GASF}}$  and  $\text{Frac}_{\text{GASM}}$ ) were verified by using the reported ammonium and nitrogen-oxides emissions from synthetic fertilizer and animal manure use to the UNECE/LRTRAP Convention.  $\text{NH}_3$  emissions from fertilizer use and animal husbandry are calculated using the Tier 2 methodology, whereas  $\text{NO}_x$  emissions are calculated according to the Tier 1 methodology of the CORINAIR Guidebook (EEA, 2009). (It has to be noted that Tier 2 methodology for  $\text{NO}_x$  emission from fertilizer use is not provided in the CORINAIR Guidebook.) The difference between the reported  $\text{N}_2\text{O}$  emissions from 3.D.3.1 Atmospheric deposition and the calculated value based on the reported  $\text{NH}_3$  and  $\text{NO}_x$  emissions is not significant for the year 2012 (0.03 Gg  $\text{N}_2\text{O}$ ), though differences are significant separately for fertilizer use and animal manure. Atmospheric deposition from the fertilizer use seems to be highly overestimated for some years in the GHG-inventory using the IPCC default value for  $\text{Frac}_{\text{GASF}}$ , while atmospheric deposition from animal manure might have been underestimated as it reveals from the estimation of  $\text{NH}_3$  and  $\text{NO}_x$  emissions from animal husbandry. The under- and overestimations counterbalanced each other in the recent years of the time-series, resulting in insignificant differences.

The main driver of the GHG-emissions from the agriculture sector is the N-fertilizer use in Hungary. Therefore the verification of the amount of N-fertilizer applied is very essential in the QA/QC process in the Agriculture sector.

The amount of the N-fertilizer applied has been compared with the international statistics, namely FAO and IFA (International Fertilizer Industry Association). There is not any difference between the reported N-fertilizer used in the FAO statistics and the GHG-inventory. However, the IFA reports higher N-fertilizer use for the years before 2007. The reasons for it have already been investigated by the experts of the HCSO and the Research Institute of Agricultural Economics and IFA's.

The fertilizer consumption data used in the GHG inventory derives from the HCSO's official statistics. HCSO gets these data from the data collection of the Research Institute of Agricultural Economics. The Research Institute of Agricultural Economics collects data on the sold amount of the different types of fertilizers. The IFA used an expert judgement for the estimation of fertilizer consumption data made by the Yara's (a Norwegian chemical company) experts, recently. The IFA's methodology for expert judgement is based on the sowing area of the main crops, such as cereals, maize and sunflower and so on. The estimation took into account the area and the fertilizer need requirements of these crops. Unfortunately, the fertilizer consumption in Hungary is generally lower than the suggested amount, due to the high price of the fertilizer. So, this methodology of IFA resulted in an overestimation.

The HCSO's, the Research Institute of Agricultural Economics' and the YARA's experts consulted on this issue in 2012, and consequently the IFA revised the applied methodology. So, as an outcome of this consultation the IFA's data for the years 2007 onwards are not higher than the official statistic of Hungary.

For the general procedure of the QC see 6.1.5.

### 6.5.5 Source-specific recalculations

Revised N-excretion values and crop residue parameters have led to recalculations for this sub-category throughout the time-series resulted in generally a net slight increase in the emissions and a small decrease for the year 1985 from 4.D. Agriculture Soils.

The overall effect of the recalculations on the emissions from 4.D is presented in Table 6.5.6. The percentage changes in emissions range between 0.0 to 1.6 per cent for the period 1986-2011 and is -0.1% for the year 1985.

**Table 6.5.6** The effect of the recalculations on N<sub>2</sub>O emissions from 4.D Agricultural Soils

Year	Submission 2013 [Gg NO <sub>2</sub> -eq]	Submission 2014 [Gg NO <sub>2</sub> -eq]	Difference [Gg NO <sub>2</sub> -eq]	Percentage change
BY	32	32	-0.01	0.0%
1985	31	31	-0.04	-0.1%
1986	32	32	0.00	0.0%
1987	32	32	0.02	0.1%
1988	31	31	0.10	0.3%
1989	30	30	0.19	0.6%
1990	23	23	0.20	0.9%
1991	16	17	0.17	1.0%
1992	14	14	0.10	0.7%
1993	13	13	0.07	0.5%
1994	15	15	0.06	0.4%
1995	14	14	0.12	0.9%
1996	14	15	0.15	1.0%
1997	14	15	0.23	1.6%
1998	16	16	0.24	1.5%
1999	16	16	0.22	1.4%
2000	15	16	0.22	1.4%
2001	17	17	0.19	1.2%
2002	17	17	0.20	1.2%
2003	16	16	0.20	1.3%
2004	18	18	0.18	1.0%
2005	16	16	0.22	1.3%
2006	17	17	0.23	1.4%
2007	17	17	0.22	1.3%
2008	17	17	0.16	0.9%
2009	16	16	0.16	1.0%
2010	16	16	0.17	1.1%
2011	16	17	0.12	0.7%

### 6.5.6 Planned improvements

Introduction of methodologies provided in the IPCC 2006 Guideline is planned.

## 6.6 Prescribed Burning of Savannas (CRF Sector 4.E)

Category 4.E Prescribed Burning of Savannas is not relevant to Hungary therefore notation keys 'NO' is used in relation to all associated emissions in CRF Tables.

Following a recommendation from the annual inventory review conducted in 2012, the notation key 'NA' was replaced by 'NO' relating to these emissions in the CRF Tables. Unfortunately, this recalculation information was provided in the chapter of Field Burning of Agricultural Residues due to lack of separate chapter of CRF Sector 4.E in the NIR, 2013 leading to another potential recommendation of the latest UNFCCC reviews, namely providing the recalculation information in the appropriate chapter. Thus, for the submission 2014 the NIR is supplemented with this new chapter, where all the required information is provided.

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

### 6.7.1 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.

### 6.7.2 Methodological issues

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

### 6.7.3 Uncertainties and time-series consistency

-

**6.7.4 QA/QC Information**

See 6.1.5.

**6.7.5 Source-specific recalculations**

Emissions from field burning of sugar cane were reported as 'NA' in the previous submissions. For this submission notation keys 'NA' were replaced by 'NO' in relation to all associated emissions from sugar cane, because cropping of this plant is not relevant to Hungary. This correction was in line with a potential recommendation of the last inventory review.

**6.7.6 Planned improvements**

There are no further improvements planned.

## 6.8 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 rizsgazat 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., Németh, Tímea, Kukovics, S. 2010. Analysis of GHG emissions from sheep sector compared with the features of cattle sector. In: Kukovics, S. – Jávör, 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)

EEA (2007): EMEP/CORINAIR Emission Inventory Guidebook-2007. European Environment Agency. <http://www.eea.europa.eu/publications/EMEPCORINAIR5/page019.html>

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.

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] (2011): 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>

HCSO [Hungarian Central Statistical Office] (2012): Mezőgazdaság, 2011. [Agriculture, 2011]. ( in Hungarian) <http://www.ksh.hu/docs/hun/xftp/idoszaki/mezo/mezo11.pdf>

HCSO [Hungarian Central Statistical Office] (2012): Stadat-tables – Times series of annual data 4. Economic sectors. 4.1. Agriculture. <http://portal.ksh.hu/>

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 Commision] (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.

Mészáros Gy., (2005): Tanácsadási füzetek a nemzeti vidékfejlesztési terv intézkedéseihez. I-II.

Pazsiczki, I. et al (2006): Trágyatárolással összefüggő technikai ismeretek a Nitrát Direktívában (ND) megfogalmazott kritériumok alapján és elvárások figyelembevételével.

Pazsiczki, I., Department for Mechanization of Animal Production, Hungarian Institute of Agricultural Engineering (2008): Expert judgement, verbal communication.

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.

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 UNFCC and of the applied methodology*] Budapest. 27 p. (unpublished, in Hungarian)

Soliva, R. (2006): Report to the attention of IPCC about the data set and calculation method used to estimate methane formation from enteric fermentation of agricultural livestock population and manure management in Swiss agriculture. Institute of Animal Science Animal Nutrition ETH Zurich Switzerland.

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 J., senior researcher, Department of Ruminant Nutrition, Research Institute for Animal Breeding and Nutrition (2004). 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)

Zsembeli et. al. (2011): Determination of country-specific values of the crop residue rate, dry matter content and Nitrogen content of crop residue of oilseed rape and sunflower. (Project report)

Zsembeli et. al. (2011). Determination of country-specific values of the crop residue rate, dry matter content and nitrogen content of crop residue of oilseed rape and sunflower.

## 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.

To fulfill the requirements of completeness the Hungarian inventory compilers have made significant effort to estimate emissions from the previously not reported land-use categories and pools for this submission. Despite the inclusion of new sources the overall change in the reported removals is insignificant, because of the low significance of the newly estimated sources.

In 2012 the net removal from the LULUCF category amounted to 4,407 Gg CO<sub>2</sub> equivalent. The estimated emissions and removals by gases over the period 1985-2012 are presented in Table 7.1.1.

**Table 7.1.1 Emissions and removals by gas from LULUCF 1985-2012 (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	-2,594	1.46	0.03	0.38	13.23
1985	-1,036	1.47	0.02	0.38	13.22
1986	-3,194	1.49	0.03	0.38	13.47
1987	-3,554	1.44	0.03	0.37	12.97
1988	-3,889	1.40	0.04	0.36	12.58
1989	-2,661	1.39	0.05	0.36	12.63
1990	-2,013	1.29	0.06	0.33	11.64
1991	-2,463	1.26	0.06	0.32	11.35
1992	-3,292	1.16	0.06	0.29	10.33
1993	-5,054	1.04	0.07	0.26	8.99
1994	-5,507	1.06	0.08	0.26	9.03
1995	-5,568	1.10	0.09	0.27	9.54
1996	-1,686	1.19	0.10	0.30	10.40
1997	-1,946	1.21	0.11	0.30	10.59
1998	-3,169	1.19	0.12	0.29	10.36
1999	-1,619	1.02	0.13	0.27	9.42
2000	-686	1.48	0.15	0.35	12.29
2001	-2,163	1.33	0.15	0.32	11.20
2002	-1,648	1.31	0.15	0.32	11.23
2003	-3,802	1.27	0.16	0.31	11.09
2004	-2,840	1.10	0.16	0.27	9.68
2005	-5,095	1.71	0.16	0.42	14.83
2006	-3,119	1.02	0.15	0.27	9.59
2007	-3,528	1.51	0.15	0.38	13.35
2008	-4,753	1.12	0.14	0.27	9.62
2009	-3,912	1.11	0.13	0.27	9.38
2010	-4,001	1.10	0.13	0.29	10.14
2011	-3,721	1.77	0.13	0.44	15.45
2012	-4,483	1.61	0.14	0.36	12.76
<b>Trend BY-2012</b>	<b>73%</b>	<b>10%</b>	<b>415%</b>	<b>-4%</b>	<b>-4%</b>

The LULUCF sector was a net sink of CO<sub>2</sub> in Hungary in all years from 1985 to 2012. Forest Land is a net carbon sink, whereas Wetlands and Settlements are net sources of greenhouse gases, Grassland and Cropland are net sources in some years and a net sinks in other years.

In 2012, removals from LULUCF corresponded to 6.2 per cent of total GHG emissions in Hungary (excluding LULUCF), compared to its 2.2% share in the base year. The variability of removals from LULUCF was rather high over the period 1985-2012, as shown in Table 7.1.2.

**Table 7.1.2 Trends in CO<sub>2</sub>-eq emissions/removals from LULUCF by land-uses 1985-2012**

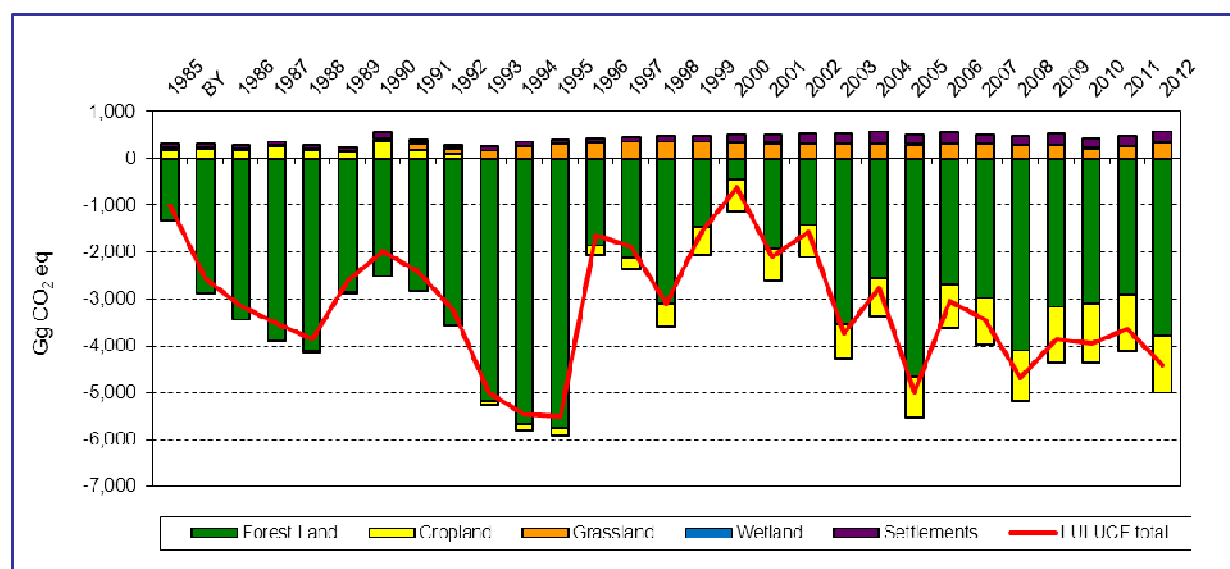
Year	GHG emissions/ removal Gg CO <sub>2</sub> -eq					
	5	5.A	5.B	5.C	5.D	5.E
BY	-2,555	-2,873	207	15	24.9	71
1985	-999	-1,319	195	40	17.5	68
1986	-3,155	-3,435	159	22	27.6	71
1987	-3,513	-3,866	267	-16	29.5	73
1988	-3,846	-4,116	183	-16	27.6	76
1989	-2,615	-2,849	137	-7	24.8	78
1990	-1,967	-2,517	365	50	22.8	112
1991	-2,417	-2,836	204	123	15.4	77
1992	-3,249	-3,551	105	123	11.4	63
1993	-5,010	-5,180	-99	160	16.8	93
1994	-5,459	-5,693	-120	259	11.0	83
1995	-5,516	-5,751	-180	305	10.8	99
1996	-1,629	-1,849	-210	329	7.4	93
1997	-1,885	-2,124	-233	357	10.4	104
1998	-3,105	-3,102	-488	356	17.2	112
1999	-1,556	-1,465	-577	357	13.2	116
2000	-609	-447	-680	335	9.9	173
2001	-2,088	-1,936	-667	321	8.9	186
2002	-1,573	-1,422	-685	317	10.6	206
2003	-3,727	-3,538	-733	308	9.3	227
2004	-2,768	-2,572	-789	312	9.4	272
2005	-5,009	-4,666	-860	303	9.9	203
2006	-3,051	-2,687	-918	314	9.8	229
2007	-3,450	-2,971	-992	312	9.6	192
2008	-4,686	-4,100	-1,080	290	9.6	194
2009	-3,847	-3,172	-1,201	293	9.6	223
2010	-3,939	-3,108	-1,263	230	9.6	193
2011	-3,642	-2,910	-1,217	260	9.6	215
2012	-4,407	-3,784	-1,212	351	9.6	229
Share in Hungarian total, in BY	2.2%	2.5%	0.2%	0.01%	0.022%	0.06%
Share in Hungarian total, in 2012	6.2%	5.1%	1.9%	0.5%	0.0%	0.4%
Trend BY-2012	72%	32%	-686%	2215%	-62%	223%

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 are less than 3% of the national total in 2012.

Although the reported emissions/removals from 5.B Cropland, 5.C Grassland, 5.D Wetland and 5.E Settlements are insignificant, their trends are significant, particularly for Grassland as shown in Table 7.1.2. 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 Cropland, 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 trends in the emissions from Cropland, Grassland and Settlements. In the case of Forest Land this saturation problem does not influence the trend in the emissions/removals.

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, 5.D 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 1046 Gg C in 2012. The living biomass in Cropland was a net sink of 13 Gg C. Mineral soils in croplands were a sink of 333 Gg C as a result of the abandonment of approximately 450 kha cropland and the soil conservation tillage practices. Grassland was a source of 349 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 228 Gg CO<sub>2</sub> in 2012. The decreasing area of peat extractions on Wetlands were a source of 9.6 Gg CO<sub>2</sub> in 2012. Liming in agricultural soils contributed 13 Gg CO<sub>2</sub> to the emissions in 2012. In addition, the non-CO<sub>2</sub> emissions from biomass burning were 1.6 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 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 0.1 Gg N<sub>2</sub>O in 2012.



**Figure 7.1.1** Trend in emissions/removals from LULUCF

### 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 the 2014 submission Hungary reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 5.A), Cropland (CRF 5.B), Grassland (CRF 5.C), Wetlands (CRF 5.D) and Settlements (CRF 5.E). 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 does not include emission estimates from Other Land (CRF 5F), because 'Other Land' category contains unmanaged areas, according to the national definition of this category. In this category only area data is reported. Non-CO<sub>2</sub> emissions from drainage of soils and Wetlands (CRF 5(II)) are not reported, because this is an optional reporting category, therefore the notation key NA and NO were used in CRF Table 5 (II).

### 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, and emissions from mineral soils for all land-use categories, while Tier 1 methodology is used in case of cropland and grassland biomass and wetland soils.

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 A3.3.)

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 (Forest Directorate of the National Food Chain Safety Office hereafter referred to as NFCSO), 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://www.ksh.hu/docs/hun/xstadat/xstadat\\_eves/i\\_omf001a.html](http://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_omf001a.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 NFCSO, 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:

- National Forestry Database
- HCSO land-use statistics
- 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 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

<sup>3</sup> In Hungarian terms kitchen garden means vegetable garden.

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 unmanaged 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

Wetlands area matches with the wetlands and water body categories of the CORINE land-cover databases. It contains 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.).

#### 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 7.2.1 shows the land-use changes over the period 1985 to 2011 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. 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 A3-3.

Following a potential recommendation arising from the centralized review in 2013, Table 7.2.1 provides data on the area of annual land-use changes by land use change categories. Note that data reported in the land converted to forest land (L-FL) category and forest land remaining forest land (FL-FL) category in Table 7.2.1 differ from those that are reported in the CRF tables. The reason for these differences is that, each year, the forest inventory identifies (“finds”) forest areas that are additional to the net changes of afforestations/reforestations and deforestations. The vast majority of this additional increase of the forest area is due to natural expansion of forests (about 20% of the cases), re-classification of land (about 60% of the cases) and geodesic re-measurements of previously existing stands at subsequent surveys (about 20% of the cases). To allocate the area of these newly identified forests, it was necessary to introduce an additional land category of “found forests” (FF).

As it is not known whether these forests are the results of human induced afforestation activity, and because they have not been established in the year of identifying them, their area is reported in the CRF tables in the FL-FL category. For further information on found forests, see Section 7.3 of the NIR.

**Table 7.2.1 Land use matrices 1985-2012 (ha)**

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	1,755,314	95	21	0	210	0
Cropland	8,002	5,465,741	5,338	0	838	0
Grassland	2,421	4,910	1,278,377	298	391	0
Wetlands	11	0	0	252,041	14	0
Settlements	84	9	117	23	526,563	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	1,765,507	95	21	0	210	0
Cropland	8,508	5,461,409	0	0	838	0
Grassland	2,575	7,366	1,273,223	298	391	0
Wetlands	12	0	0	252,337	14	0
Settlements	90	9	117	23	527,777	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	1,776,365	95	21	0	210	0
Cropland	8,552	5,459,489	0	0	838	0
Grassland	2,588	7,366	1,262,719	298	391	0
Wetlands	12	0	0	252,632	14	0
Settlements	90	9	117	23	528,991	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	1,787,281	95	21	0	210	0
Cropland	10,767	5,455,353	0	0	838	0
Grassland	3,258	7,366	1,251,544	298	391	0
Wetlands	15	0	0	252,924	14	0
Settlements	114	9	117	23	530,182	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	1,800,822	180	40	0	393	0
Cropland	9,950	5,452,034	0	0	838	0
Grassland	3,011	7,366	1,240,617	298	391	0
Wetlands	14	0	0	253,218	14	0
Settlements	105	9	117	23	531,381	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	1,813,662	60	13	0	167	0
Cropland	8,932	5,433,806	16,013	0	838	0
Grassland	2,703	0	1,237,382	298	391	0
Wetlands	12	0	0	253,512	14	0
Settlements	94	9	117	23	532,773	0
Other Land	0	0	0	0	0	2,444
<b>1991</b>	<b>1,825,404</b>	<b>5,433,875</b>	<b>1,253,526</b>	<b>253,834</b>	<b>534,184</b>	<b>2,444</b>

**Table 7.2.1 Land use matrices 1985-2012 (ha) (continued)**

<b>1991</b>	<b>1,825,404</b>	<b>5,433,875</b>	<b>1,253,526</b>	<b>253,834</b>	<b>534,184</b>	<b>2,444</b>
Forest Land	1,825,278	44	9	0	72	0
Cropland	9,936	5,407,087	16,013	0	838	0
Grassland	3,007	0	1,249,830	298	391	0
Wetlands	14	0	0	253,806	14	0
Settlements	105	9	117	23	533,928	0
Other Land	0	0	0	0	0	2,444
<b>1992</b>	<b>1,838,339</b>	<b>5,407,141</b>	<b>1,265,970</b>	<b>254,127</b>	<b>535,244</b>	<b>2,444</b>
Forest Land	1,838,011	13	83	0	233	0
Cropland	6,705	5,392,792	6,707	0	938	0
Grassland	1,361	8,269	1,255,444	597	297	1
Wetlands	18	0	0	254,101	8	0
Settlements	244	28	178	16	534,779	0
Other Land	0	0	0	0	0	2,444
<b>1993</b>	<b>1,846,338</b>	<b>5,401,101</b>	<b>1,262,412</b>	<b>254,714</b>	<b>536,255</b>	<b>2,445</b>
Forest Land	1,846,120	28	27	0	163	0
Cropland	4,847	5,388,609	6,707	0	938	0
Grassland	984	8,269	1,252,264	597	297	1
Wetlands	13	0	0	254,693	8	0
Settlements	176	28	178	16	535,857	0
Other Land	0	0	0	0	0	2,445
<b>1994</b>	<b>1,852,141</b>	<b>5,396,934</b>	<b>1,259,176</b>	<b>255,305</b>	<b>537,263</b>	<b>2,446</b>
Forest Land	1,851,783	53	61	0	244	0
Cropland	7,760	5,381,530	6,707	0	938	0
Grassland	1,576	8,269	1,248,437	597	297	1
Wetlands	21	0	0	255,276	8	0
Settlements	282	28	178	16	536,759	0
Other Land	0	0	0	0	0	2,446
<b>1995</b>	<b>1,861,421</b>	<b>5,389,880</b>	<b>1,255,383</b>	<b>255,889</b>	<b>538,247</b>	<b>2,447</b>
Forest Land	1,861,075	79	79	0	188	0
Cropland	8,591	5,373,644	6,707	0	938	0
Grassland	1,744	8,269	1,244,474	597	297	1
Wetlands	23	0	0	255,858	8	0
Settlements	312	28	178	16	537,713	0
Other Land	0	0	0	0	0	2,447
<b>1996</b>	<b>1,871,746</b>	<b>5,382,020</b>	<b>1,251,438</b>	<b>256,471</b>	<b>539,144</b>	<b>2,447</b>
Forest Land	1,871,224	192	90	0	240	0
Cropland	9,940	5,364,435	6,707	0	938	0
Grassland	2,018	8,269	1,240,256	597	297	1
Wetlands	27	0	0	256,436	8	0
Settlements	361	28	178	16	538,561	0
Other Land	0	0	0	0	0	2,447
<b>1997</b>	<b>1,883,569</b>	<b>5,372,924</b>	<b>1,247,232</b>	<b>257,049</b>	<b>540,044</b>	<b>2,448</b>
Forest Land	1,883,167	89	42	0	271	0
Cropland	8,691	5,356,588	6,707	0	938	0
Grassland	1,765	8,269	1,236,303	597	297	1
Wetlands	23	0	0	257,017	8	0
Settlements	316	28	178	16	539,506	0
Other Land	0	0	0	0	0	2,448
<b>1998</b>	<b>1,893,962</b>	<b>5,364,974</b>	<b>1,243,230</b>	<b>257,630</b>	<b>541,021</b>	<b>2,449</b>

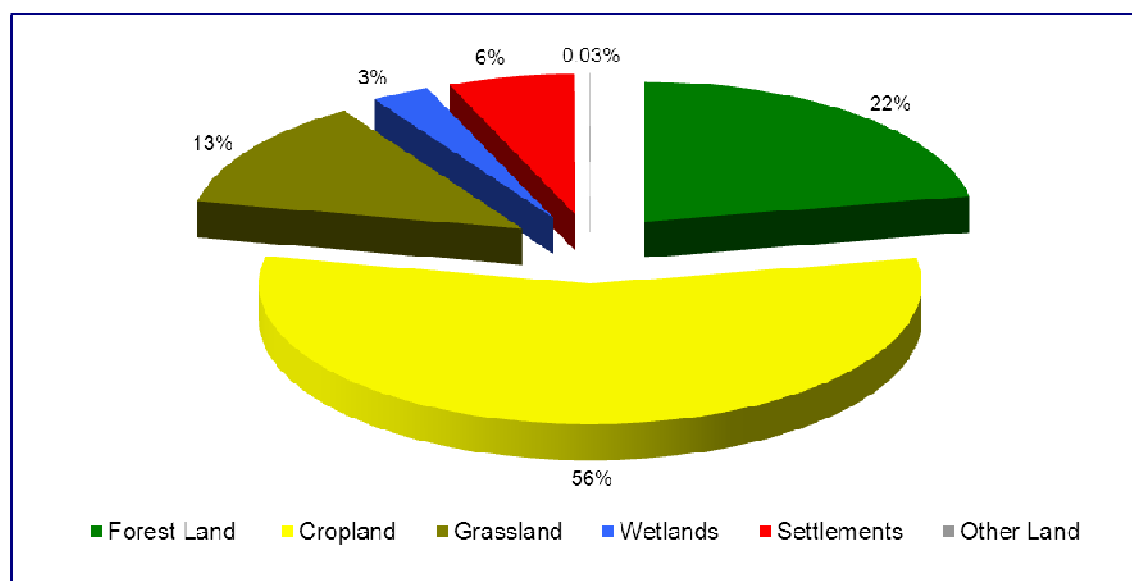
**Table 7.2.1 Land use matrices 1985-2012 (ha) (continued)**

<b>1998</b>	<b>1,893,962</b>	<b>5,364,974</b>	<b>1,243,230</b>	<b>257,630</b>	<b>541,021</b>	<b>2,449</b>
Forest Land	1,893,566	27	91	0	278	0
Cropland	11,228	5,346,101	6,707	0	938	0
Grassland	2,280	8,269	1,231,786	597	297	1
Wetlands	30	0	0	257,591	8	0
Settlements	408	28	178	16	540,391	0
Other Land	0	0	0	0	0	2,449
<b>1999</b>	<b>1,907,512</b>	<b>5,354,425</b>	<b>1,238,762</b>	<b>258,204</b>	<b>541,912</b>	<b>2,450</b>
Forest Land	1,906,793	68	56	0	595	0
Cropland	11,575	5,335,205	6,707	0	938	0
Grassland	2,350	8,269	1,227,248	597	297	1
Wetlands	31	0	0	258,165	8	0
Settlements	421	28	178	16	541,270	0
Other Land	0	0	0	0	0	2,450
<b>2000</b>	<b>1,921,170</b>	<b>5,343,570</b>	<b>1,234,189</b>	<b>258,778</b>	<b>543,108</b>	<b>2,451</b>
Forest Land	1,920,649	61	101	0	359	0
Cropland	13,630	5,326,128	1,847	0	1,965	0
Grassland	2,479	2,985	1,227,700	487	538	0
Wetlands	10	0	0	258,732	35	0
Settlements	177	1	119	30	542,781	0
Other Land	0	0	0	0	0	2,451
<b>2001</b>	<b>1,936,944</b>	<b>5,329,175</b>	<b>1,229,768</b>	<b>259,249</b>	<b>545,679</b>	<b>2,451</b>
Forest Land	1,936,307	109	89	0	439	0
Cropland	15,786	5,309,578	1,847	0	1,965	0
Grassland	2,871	2,985	1,222,887	487	538	0
Wetlands	12	0	0	259,202	35	0
Settlements	205	1	119	30	545,324	0
Other Land	0	0	0	0	0	2,451
<b>2002</b>	<b>1,955,180</b>	<b>5,312,672</b>	<b>1,224,942</b>	<b>259,719</b>	<b>548,302</b>	<b>2,451</b>
Forest Land	1,954,587	26	44	0	523	0
Cropland	10,862	5,297,998	1,847	0	1,965	0
Grassland	1,976	2,985	1,218,956	487	538	0
Wetlands	8	0	0	259,675	35	0
Settlements	141	1	119	30	548,011	0
Other Land	0	0	0	0	0	2,451
<b>2003</b>	<b>1,967,573</b>	<b>5,301,010</b>	<b>1,220,967</b>	<b>260,192</b>	<b>551,073</b>	<b>2,451</b>
Forest Land	1,966,629	74	119	0	750	0
Cropland	11,938	5,285,260	1,847	0	1,965	0
Grassland	2,171	2,985	1,214,786	487	538	0
Wetlands	9	0	0	260,148	35	0
Settlements	155	1	119	30	550,768	0
Other Land	0	0	0	0	0	2,451
<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	1,980,491	71	27	0	313	0
Cropland	2,333	5,282,175	1,847	0	1,965	0
Grassland	424	2,985	1,212,437	487	538	0
Wetlands	2	0	0	260,628	35	0
Settlements	30	1	119	30	553,877	0
Other Land	0	0	0	0	0	2,451
<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>

**Table 7.2.1 Land use matrices 1985-2012 (ha) (continued)**

<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	1,982,771	44	21	0	443	0
Cropland	13,132	5,268,287	1,847	0	1,965	0
Grassland	2,389	2,985	1,208,031	487	538	0
Wetlands	10	0	0	261,099	35	0
Settlements	170	1	119	30	556,409	0
Other Land	0	0	0	0	0	2,451
<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	1,998,227	16	37	0	192	0
Cropland	20,034	5,247,472	1,847	0	1,965	0
Grassland	933	2,985	1,205,075	487	538	0
Wetlands	0	0	0	261,581	35	0
Settlements	0	1	119	30	559,241	0
Other Land	0	0	0	0	0	2,451
<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	2,018,900	98	35	0	160	0
Cropland	11,026	5,235,635	1,847	0	1,965	0
Grassland	643	2,985	1,202,425	487	538	0
Wetlands	0	0	0	262,062	35	0
Settlements	260	1	119	30	561,561	0
Other Land	0	0	0	0	0	2,451
<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	2,030,374	56	103	0	296	0
Cropland	8,103	5,226,804	1,847	0	1,965	0
Grassland	696	2,985	1,199,721	487	538	0
Wetlands	0	0	0	262,544	35	0
Settlements	174	1	119	30	563,936	0
Other Land	0	0	0	0	0	2,451
<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	2,039,138	59	47	0	102	0
Cropland	6,292	5,219,742	1,847	0	1,965	0
Grassland	373	2,985	1,197,408	487	538	0
Wetlands	0	0	0	263,025	35	0
Settlements	592	1	119	30	566,029	0
Other Land	0	0	0	0	0	2,451
<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>
Forest Land	2,046,118	67	24	0	185	0
Cropland	3,898	5,215,077	1,847	0	1,965	0
Grassland	582	2,985	1,194,829	487	538	0
Wetlands	0	0	0	263,507	35	0
Settlements	65	1	119	30	568,456	0
Other Land	0	0	0	0	0	2,451
<b>2011</b>	<b>2,050,662</b>	<b>5,218,130</b>	<b>1,196,820</b>	<b>264,024</b>	<b>571,179</b>	<b>2,451</b>
Forest Land	2,049,880	113	389	0	280	0
Cropland	5,004	5,209,313	1,847	0	1,965	0
Grassland	663	2,985	1,192,147	487	538	0
Wetlands	0	0	0	263,988	35	0
Settlements	85	1	119	30	570,944	0
Other Land	0	0	0	0	0	2,451
<b>2012</b>	<b>2,055,632</b>	<b>5,212,413</b>	<b>1,194,502</b>	<b>264,505</b>	<b>573,763</b>	<b>2,451</b>

Figure 7.2.1 shows the distribution of the net areas of the six, broad IPCC land-use categories in Hungary in 2012. Cropland is the dominant land-use category in all years, accounting for 56 per cent of the total area of Hungary in 2012, 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. 714 thousand hectares Cropland and 488 thousand hectares Grassland were abandoned, and the Forest Land area increased by 300 thousands hectares over the period from 1985-2012.



**Figure 7.2.1** Distribution of IPCC land-use categories in Hungary in 2012

## 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 and stock-change 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 and emissions from mineral soil for which country-specific values are applied.

### 7.3 Forest Land (CRF sector 5.A)

This section describes forests and forestry in Hungary, as well as methodologies of estimating GHG emissions and removals in the forestry sector. The description covers all information related to reporting under the UNFCCC, but this information is also used to develop supplementary information reported in Section 11. On the other hand, some information is reported in more details in Section 11. Thus, the consideration of both sections is necessary to understand the information on methods and data in this section.

Forest land is managed in Hungary by a system of relatively stringent planning and inspecting system. A general description of this system together with a general description of the Hungarian forests can be found at

[http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/forest-db.html](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/forest-db.html). Additional information on the Forest Monitoring and Observation System, can be found at [http://www.nebih.gov.hu/data/cms/140/962/FMOS\\_final.pdf](http://www.nebih.gov.hu/data/cms/140/962/FMOS_final.pdf).

Forest land information is collected and stored in a cadaster-type system. A detailed description of forestry-related databases of NFCSD FD (National Food Chain Safety Office, Forestry Directorate) in English at, <https://www.nebih.gov.hu/en/specialities/erdeszeti>, [https://www.nebih.gov.hu/data/cms/161/750/Forest\\_resources\\_and\\_forest\\_management\\_in\\_Hungary\\_2013.pdf](https://www.nebih.gov.hu/data/cms/161/750/Forest_resources_and_forest_management_in_Hungary_2013.pdf) and at

[http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT). Forests are managed in units, of relatively homogenous tree cover, i.e. stands, with a mean area of about four ha. The geographical location of all known stands, that are sometimes called sub-compartments can be identified (in Hungarian) at <http://erdoterkep.nebih.gov.hu/>. Further data and information, mainly in Hungarian, can also be found on the website of the NFCSD at [http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag). Additional data and information that are used for the GHG inventory and that are not at the website are found in the documentation of the forest inventory. Finally, additional information concerning data, methods and demonstrating specific procedures (often specifically developed for the Expert Review Teams) can be found at [http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT).

Forest land covers more than one fifth of the terrestrial area of the country. The total land under forest management, which is considered as forest land area, includes forest sub-compartments that at least potentially are covered by trees, as well as un-stocked areas like roads, openings, wildlife forage grounds, glades, buildings serving forest management purposes etc. The area of forest land using this definition was 2,055.6 thousand ha by the end of 2012. 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 sub-compartments (i.e. the potentially stocked area) amounted to 1,933.6 thousand ha. The area actually covered by trees (i.e. the actually stocked area), which appears in several official Hungarian statistics, amounted to 1,861.7 thousand ha. This area is calculated from that of the forest sub-compartments 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 sub-compartments, thus, the implied emission factor and m<sup>3</sup>/ha data should reflect the area of forest sub-compartments (Table 7.3.1).

**Table 7.3.1** *The area of forest land, forest compartments and land covered by trees (ha) over time.*

Reporting year	Total forest area (forest subcompartments and other, ha)	Area of forest subcompartments (ha)	Calculated area covered by trees (ha)
1985	1 755 640	1 643 276	1 505 764
1986	1 765 833	1 650 576	1 513 582
1987	1 776 691	1 659 381	1 526 395
1988	1 787 607	1 666 586	1 530 587
1989	1 801 435	1 665 551	1 551 138
1990	1 813 902	1 681 467	1 563 585
1991	1 825 404	1 694 546	1 570 750
1992	1 838 339	1 708 804	1 589 760
1993	1 846 338	1 713 763	1 599 669
1994	1 852 141	1 719 146	1 608 811
1995	1 861 421	1 727 223	1 616 716
1996	1 871 746	1 737 818	1 627 588
1997	1 883 569	1 748 358	1 642 288
1998	1 893 962	1 758 645	1 656 399
1999	1 907 512	1 773 247	1 657 827
2000	1 921 170	1 787 372	1 689 401
2001	1 936 944	1 803 922	1 697 940
2002	1 955 180	1 823 377	1 723 805
2003	1 967 573	1 836 429	1 749 246
2004	1 980 902	1 850 809	1 769 988
2005	1 983 280	1 853 183	1 789 648
2006	1 998 472	1 869 349	1 805 801
2007	2 019 194	1 890 866	1 825 953
2008	2 030 830	1 903 360	1 840 171
2009	2 039 347	1 912 917	1 853 170
2010	2 046 394	1 922 108	1 862 002
2011	2 050 662	1 927 702	1 861 033
2012	2 055 632	1 933 604	1 861 691

The total area of forests change considerably, from about 11% to 21% today, because around 800 thousand ha of forests have been established since 1930. The intensity of the afforestations (Figure 7.3.1) and deforestation (Table 7.3.2 below) change over time.

Below there is a summary of all definitions that are generally applied in the methodology to identify the above mentioned areas in various categories under the UNFCCC and the KP, and to estimate emissions and removals in these categories.

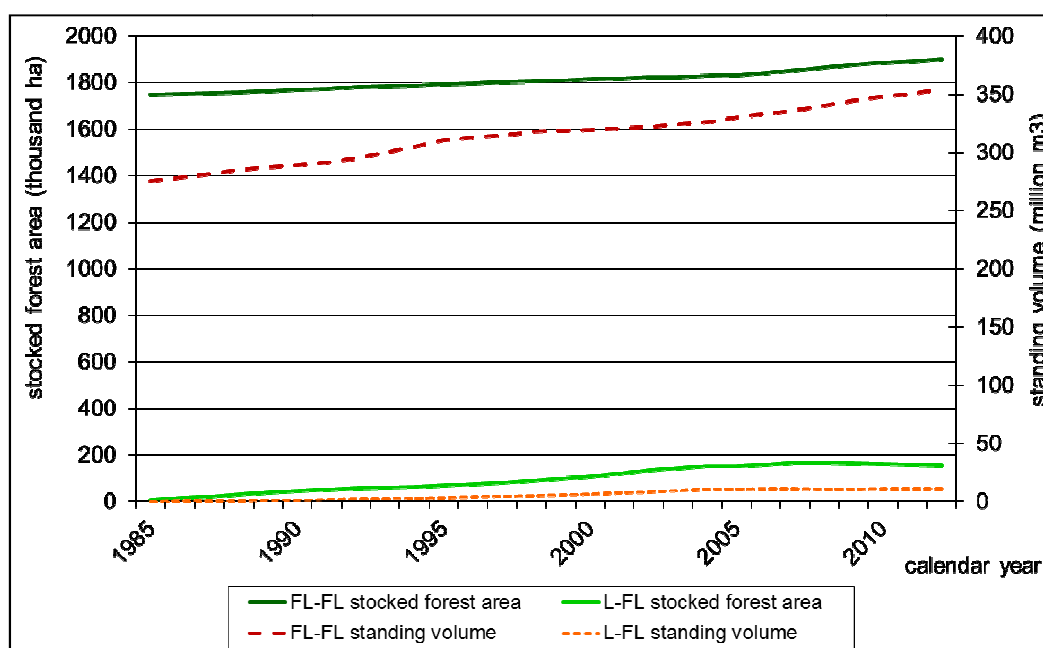
“Forest” (the area actually or potentially covered by trees) is defined in Hungary as land spanning at least 0.5 hectares with forest trees higher than five meters at maturity and a canopy cover of more than 30 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. „Forest 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 7.3.1).

“Afforestation” or “reforestation” 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 include areas in the *land converted to forest land (L-FL)* category. Note that usually different areas of forests are included in the L-FL category under the UNFCCC, which contain all administered forestations, and the *AR category* under the KP, which only includes areas where the requirement of “direct human induced activity” is fully met in the databases. (The difference between annual additions to the above two categories is small.)

“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.) All deforested land in each year is registered in the *forest land converted to other land uses (FL-L)* category under the UNFCCC. Note that the same area is applied in the *deforestation (D)* category under the KP.

Forest management has a long history in the country, too, and most forests are more or less intensively managed. The amount of forests that could be considered as “unmanaged” under the UNFCCC is rather little. 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 as we also consider forest monitoring, inspecting, forest protection, forest tourism and game management as forest management activities, and these may take place even in forest reserves. Therefore, all reported forests of Hungary are considered as managed under the UNFCCC. However, there are some forests that forest management surveys identify each year as new forests, and as we know very little about how these forests were established and how they have been managed until they are found, we have considered them as forests that do not meet the requirements (for human induced activities) under the Kyoto Protocol (“found forests”, see section 11).



**Figure 7.3.1** The area and standing 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 were recalculated in the 2012 submission (see text below).

The basis of **land identification** is a field-based, GIS-supported, continuous forest inventory whose main aim is to support the development of forest management plans and the inspection of forestry activities in the forests. The units of the planning are the sub-compartments. During planning, practically all *forest stands are surveyed once in every 10 years* (see with more details at [https://www.nebih.gov.hu/data/cms/132/554/forest\\_planning\\_districts\\_in\\_2005.pdf](https://www.nebih.gov.hu/data/cms/132/554/forest_planning_districts_in_2005.pdf)), 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 dendrometrical 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 volume stocks of the forests due to any causes from growth through harvests and natural disturbances to 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 by using annualized updating. For statistics on tracking forest land, see detailed annual accounts at [https://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/statistics.html](https://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/statistics.html). (Note that the statistics are only produced in Hungarian, and are demonstrated at the cited webpage as “statistics for the report under the Kyoto Protocol”, but they cover all known forests in the country.) In addition to the area information, the forest inventory statistics include, and have always included, all losses of volume stocks due to all deforestations. *Carbon stock changes due to deforestations, but also due to afforestations and all other forest areas are thus reported separately in this inventory.*

For this report, the Forestry 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 area of operation, and these estimates were totaled 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 only 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 seven kha annually. The reason for these area dynamics is that the Hungarian Forest Law is really rather rigorous and is also rather strictly implemented and inspected with respect to the deforestations, whereas afforestations are needed to increase forest resources, the amount of which is less than e.g. the average of the European Union. 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 7.3.2** *The area of, and emissions from conversion of forest land to other land use categories, which is equivalent to deforestation under the Kyoto Protocol, over time. The annual area has been slightly fluctuating e.g. because of varying rate of highway building, 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
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
2011	276.6	45.7
2012	782.4	131.6

In principle, all changes of the area of the FL-FL subcategory are due to afforestations/reforestations and deforestations. In Hungary, however, the sum of the areas of all these conversions has been less than the total changes (i.e. net increases in each year so far) 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. 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”, it is necessary to introduce an additional land category in case the stock difference method is used to estimate biomass carbon stock changes. As we apply this method, we need to apply the category of “*found forests*” (FF). This is also necessary as its area is relatively large, i.e. on average about half of annual afforestations (see Figure 11.1).

In another words, 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. As this total area is different in consecutive years, the difference, i.e. what is found

must be kept separate.

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 effectively resulted in a limited extent of forest area reductions that could not be captured.

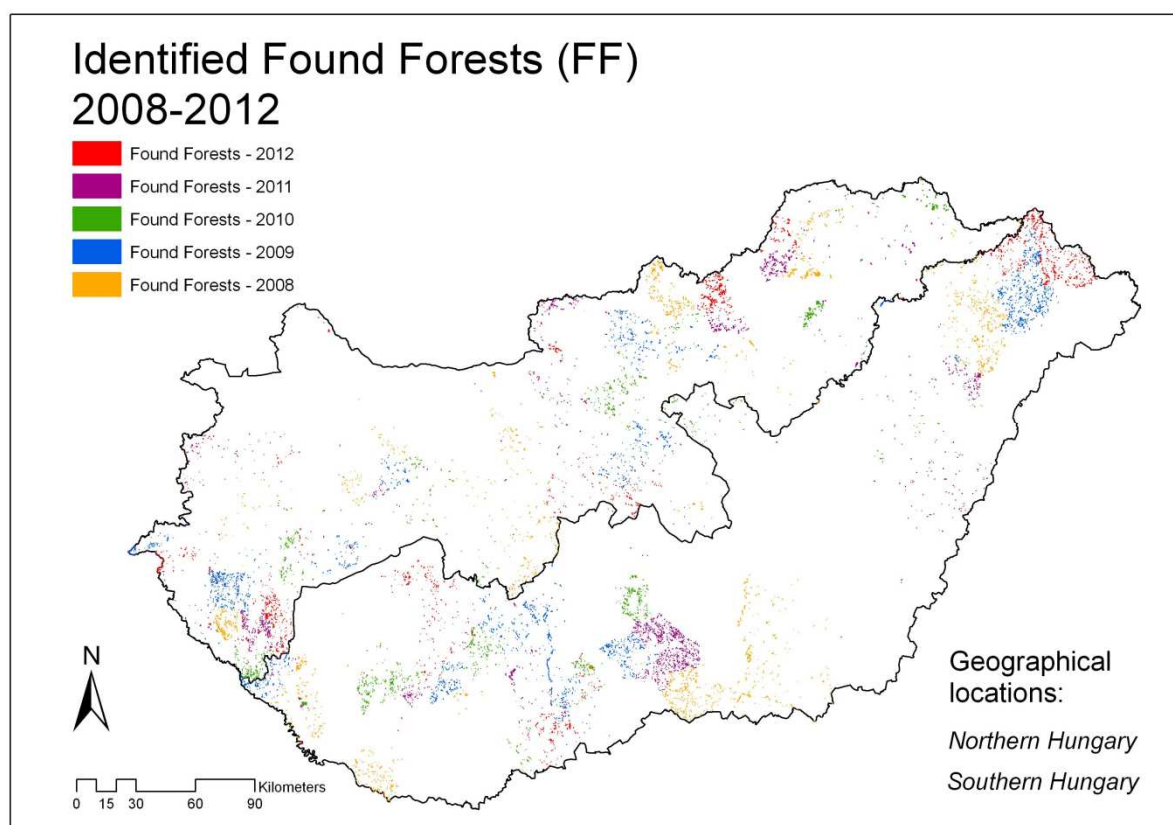
On the other hand, there were processes that resulted in an “increase” of the forest area over the past decades. This increase was only captured at subsequent forest surveys, and was not regarded so much important to track. The vast majority of this “increase” is due to the following processes and causes:

- natural expansion of the forest area, i.e. natural establishment of stands (about 20% of the cases), sometimes resulting in an increase of the size of an area beyond that of the “forest” threshold,
- re-classification of land (i.e., areas of former “croplands”, “grasslands” or “settlements” etc. that are found during a repeated survey to be covered by trees, possibly due to unregistered earlier afforestation, beyond the thresholds of the Forest act and that thus had to be reclassified as “forests”, about 60% of the cases),
- geodesic re-measurements of previously existing stands at subsequent surveys (about 20% of the cases).

Note that the area of some FFs cannot be broken down to stands at the moment.

The found changes of the total forest area in any inventory year are thus only partly physical and actual increases of the “forest” area, but partly 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).

Most stands in the FF category have been identifiable individually since 2008, their area being 5567, 6495, 3182, 4224 and 5520 ha (see also Figure 7.3.2). A complete assessment of FF with respect to the area and carbon stock changes in 2012 is presented in Chapter 11.2.2.



**Figure 7.3.2** The distribution of found forests (FF) 2008-2012.

As mentioned earlier, the newly identified FF must be excluded from the FL-FL subcategory in each inventory 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 were not yet known then. However, 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 (FM) under the Kyoto Protocol when the beginning of the period of the definition of Forest Management, i.e. 1990, is fixed.

To demonstrate the steps of allocating forest area into the various land use and land use change category, we include here Table 7.3.3.

**Table 7.3.3** The algorithm of allocating area to the various land use and land use change categories, together with the estimated area (ha) by inventory year for the last several years.

In the table and the formulas,  $t_1$  means the beginning of the year (i.e., the end of the preceding year), whereas  $t_2$  means the end of the year. The light yellow color in some cells of the table (with column title "from DB") shows that the data in those cells are taken from the database (i.e., they are the result of other calculations), whereas data in white cells are calculated in this table. FL = Forest Land; FL-FL: Forest land remaining forest land; L-FL: Land converted to forest land; FF: found forest; D: deforestation.  $\Delta$  is used to denote changes of the value of a land use class between two time points, or changes estimated by using another methodology. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	AREA, ha										
	FL, all compartments			D	new FF	L-FL			FL-FL		
	FL = FL-FL + L-FL + new FF										
	t1	t2	Δ	Δ	Δ	t1	Δ	t2	t1	t2, w/o FF	t2, w/ FF
	from DB	from DB	t2-t1	from DB	from DB	from DB	from DB	t1 + Δ	FL - L-FL	FL - L-FL	FL - L-FL
2008	2 019 194	2 030 830	11 636	294	5 567	167 556	-1 562	165 994	1 851 638	1 859 269	1 864 835
2009	2 030 830	2 039 347	8 517	450	6 495	165 994	-2 406	163 588	1 864 835	1 869 263	1 875 758
2010	2 039 347	2 046 394	7 048	208	3 136	163 588	-1 683	161 905	1 875 758	1 881 353	1 884 489
2011	2 046 394	2 050 662	4 267	277	4 224	161 905	-3 703	158 202	1 884 489	1 888 236	1 892 459
2012	2 050 662	2 055 632	4 971	782	5 520	158 202	-2 556	155 647	1 892 459	1 894 465	1 899 986

**Concerning methodologies in general**, 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 its description, contain more and updated default values and are based on updated scientific basis, while being basically consistent with the GPG in terms of methodology. 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 was 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. However, beginning with the 2012 submission, after having made necessary developments in the database system, we started to apply the default transition period of 20 years to populate the Land converted to Forest Land (L-FL) category.

Note that the IPCC 1996 Revised Guidelines are also used to obtain estimates for emissions related to fires (where the GPG also makes reference to these Guidelines).

In general, we apply Tier 2 methodology with country specific data where we have any such data. We also apply "best estimates", i.e. we have made use of all data and information that exist within the country in relation to the forest GHG inventory. In all other cases, we refer to the source of the data applied (e.g. GPG, IPCC 1996 GL).

With respect to sources of activity data, it was taken from the *National Forest Database and related forestry databases*. These databases contain data by species or species group and age class. Most emission/removal factors, e.g. wood density, are available by species or species group as country specific data (arising from appropriate research projects), some data are taken from literature, while only IPCC default values were available for other factors (see below). Expert judgment is rarely applied, and mentioned each time when such expert judgment is used.

For inventory years prior to 2008, we only identified the total area of FF, and conducted a sampling of management plans to establish their specific growing stock ( $m^3/ha$ ). 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. For years 2008 and later, we are able to directly estimate the volume stock of all FF land, and thus we are able to report that the average growing stock is 126.9, 122.0, 123.4, 123.2 and 127.7 m<sup>3</sup>ha<sup>-1</sup> for the years of 2008-2012. The mean age of FF is 25.5, 22.2, 24.7, 22.9 and 22.8 years for the years of 2008-2012.

Concerning the estimation of carbon stock changes of the **biomass carbon pools**, we apply the following **definitions** (see also Section 11.3.1.1 for further details):

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

*“Below-ground biomass”* is the total biomass of the above trees minus their above-ground biomass.

With respect to estimating **carbon stock changes in the biomass pools** themselves, different approaches are used for the various categories under the UNFCCC and under the KP. The basis for all approaches is that, we first calculate carbon stocks for *all* forests for year N and year N-1. From this, the *difference* of carbon stocks is calculated (i.e. we use the stock change method). However, this is not the correct carbon stock change for all forests yet as the stocks in year N contain the stock of the newly found forests.

Therefore, in the second step, we calculate carbon *stocks* of newly found FF (from the volume found).

Third, we calculate carbon stock *changes* for L-FL (by using a specific method, see section 7.3.2), for FL-L under the UNFCCC (the latter being equal to D under the KP, see section 7.3.3, by using the carbon stock change method), as well as for AR under the KP (by using the carbon stock change method, see section 11.3.1.1).

Finally, appropriate formulas are applied to derive carbon stock changes in the FL-FL (under the UNFCCC, see Table 7.3.6) and FM (under the KP, see Table 11.4) categories.

For both FL-FL and FM, the basis of calculating carbon stock changes is thus the true carbon stock changes of all forests, which excludes the carbon stocks of newly found forests each year. All respective calculations are demonstrated by the actual equations used that are found in the referenced tables, which in turn are found in the respective sections.

Due to the nature of the Hungarian forestry statistics, estimates of total above-ground 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, carbon stock changes had been calculated, following the early advice of the IPCC 1996 Guidelines, using the “IPCC default 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 also contains 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 are aggregated by species and age classes. 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.

In order to estimate carbon stock changes of *all forests*, the first part of Equation 2.8 of the IPCC 2006 Guidelines (which is a follow-up of equation 3.2.3 of the GPG for LULUCF, IPCC 2003) is used:

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

where

$\Delta C_B$  = carbon stock changes of biomass (tonnes C)

$C_t$  = carbon stock at time t (tonnes C)

$t_1$  and  $t_2$  = (final day of) two consecutive years.

To estimate biomass carbon stocks, the second part of Equation 2.8 of the IPCC 2006 Guidelines (which is a follow-up of equation 3.2.3 of the GPG for LULUCF, IPCC 2003) has been adapted to the Hungarian conditions in the following form:

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

where:

$V_t$  = growing stock at time t ( $m^3$ )

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

$R$  = root-to-shoot ratio (dimensionless)

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

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 and updating growing stock information (using local yield tables) each year.

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. For each stands, yield functions are used in years between surveys to update volume stocks. As a result, volume carbon stocks are available for each stand and for each inventory year.

The forest inventory is conducted by the Central Agricultural Office Forestry Directorate and related government services with a staff of about 300-400 forest engineers. 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 of basic wood densities was introduced in 2010 (i.e., since inventory year 2008). This dataset (Table 7.3.4), which replaced previous data that were oven-dry density values, and which is used across all reporting years, is much more detailed by species than before, and includes basic wood densities based on a thorough revision of previous data reported in literature combined with re-measurements of wood densities for some species in a dedicated project (Somogyi, 2008).

**Table 7.3.4** 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> )
Quercus robur	0.665	0.57
Quercus pertaea	0.665	0.61
Other quercus	0.665	0.55
Quercus cerris	0.77	0.64
Fagus silvatica	0.68	0.59
Carpinus betulus	0.79	0.58
Robinia pseudoacacia	0.74	0.59
Acer sp.	0.5925	0.52
Ulmus sp.	0.5925	0.58
Fraxinus sp.	0.5925	0.56
Other hard broadleaves	0.5925	0.5
Hybrid poplars	0.37	0.34
Indigenous poplars	0.395	0.36
Salix sp.	0.33	0.36
Alnus sp.	0.56	0.43
Tilia sp.	0.56	0.48
Other soft broadleaves	0.56	0.48
Pinus silvestris	0.53	0.42
Pinus nigra	0.53	0.47
Picea abies	0.53	0.39
Larix decidua	0.53	0.49
Other conifers	0.53	0.37

Note that no biomass *expansion* factor is applied for the above-ground biomass, because all wood volume (m<sup>3</sup>) values in Hungary are estimated, and expressed, as total above-ground volume of trees including stem, all branches, twigs and bark, i.e. all above-ground parts of the trees (above stump, see above). To convert the total (above-ground) volume to (total) above ground biomass, expansion is therefore not necessary (merchantable volume is not measured anyway), and only conversion is done to estimate biomass. In order to be consistent with this approach, the above basic wood densities were measured from samples taken from all parts of trees, including branches and bark.

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 country-specific data, IPCC default values are used in connection with expert judgment (Tier 1 methodology). Considering that the majority of the forests in Hungary is young, that the average volume stocks (calculated on the basis of the area of forest sub-compartments) are 173.0 m<sup>3</sup> ha<sup>-1</sup> (in 1990) and 189.4 m<sup>3</sup> ha<sup>-1</sup> (in 2012), 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 biomass<sup>-1</sup> are used for broadleaves and coniferous species, respectively.

The estimated net removals for each land use and land use change category are reported in the relevant sections below.

Finally, the definitions and methodologies used **for other carbon pools and for estimating non-CO<sub>2</sub> emissions** are reported in the respective sub-sections as relevant.

### 7.3.1 Forest Land remaining Forest Land (CRF sector 5.A.1)

#### 7.3.1.1 Category description

The main inventory estimates for the FL-FL category can be found in Table 7.3.5. Note that, in order to be consistent with the CRF tables, only the area of forest and other sub-compartments is reported here.

Note also that data was recalculated in 2012. The largest changes were due to re-defining L-FL land by applying the default 20-yr transition period (see above), 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 changed much (see 7.3.6. section for details).

**Table 7.3.5** Area of sub-compartments, as well as emissions (+) and removals (-) in the FL-FL sub-category by gas and inventory year.

Inventory year	Area (ha)	CO <sub>2</sub> (Gg)	CH <sub>4</sub> (Gg)	CO (Gg)	N <sub>2</sub> O (Gg)	NO <sub>x</sub> (Gg)
1985	1,748,164	-1,275	1.51	13.23	0.0104	0.38
1986	1,750,861	-3,338	1.54	13.47	0.0106	0.38
1987	1,753,827	-3,718	1.48	12.97	0.0102	0.37
1988	1,756,259	-3,905	1.44	12.58	0.0099	0.36
1989	1,762,801	-2,603	1.44	12.63	0.0099	0.36
1990	1,768,774	-2,233	1.33	11.64	0.0091	0.33
1991	1,773,942	-2,510	1.30	11.35	0.0089	0.32
1992	1,780,140	-3,175	1.18	10.33	0.0081	0.29
1993	1,785,094	-4,791	1.03	8.99	0.0071	0.26
1994	1,788,184	-5,284	1.03	9.03	0.0071	0.26
1995	1,793,517	-5,307	1.09	9.54	0.0075	0.27
1996	1,797,602	-1,344	1.19	10.40	0.0082	0.30
1997	1,801,572	-1,547	1.21	10.59	0.0083	0.30
1998	1,804,219	-2,464	1.18	10.36	0.0081	0.29
1999	1,809,551	-759	1.08	9.42	0.0074	0.27
2000	1,813,966	332	1.40	12.29	0.0097	0.35
2001	1,817,339	-1,035	1.28	11.20	0.0088	0.32
2002	1,821,574	-403	1.28	11.23	0.0088	0.32
2003	1,822,625	-2,441	1.27	11.09	0.0087	0.31
2004	1,828,804	-1,441	1.11	9.68	0.0076	0.27
2005	1,831,429	-3,552	1.69	14.83	0.0116	0.42
2006	1,840,911	-1,494	1.10	9.59	0.0075	0.27
2007	1,851,638	-1,707	1.53	13.35	0.0105	0.38
2008	1,864,835	-2,917	1.10	9.62	0.0076	0.27
2009	1,875,758	-2,025	1.07	9.38	0.0074	0.27
2010	1,884,489	-1,978	1.16	10.14	0.0080	0.29
2011	1,892,459	-1,839	1.66	14.55	0.0114	0.41
2012	1,899,986	-2,721	1.46	12.76	0.0100	0.36

#### 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 (*GPG for LULUCF, IPCC 2006 Guidelines*). However, wherever it was possible, country specific data was used (Tier 2), and

IPCC default values (Tier 1) were only used in a few cases. Emissions and removals leading to changes in the biomass 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

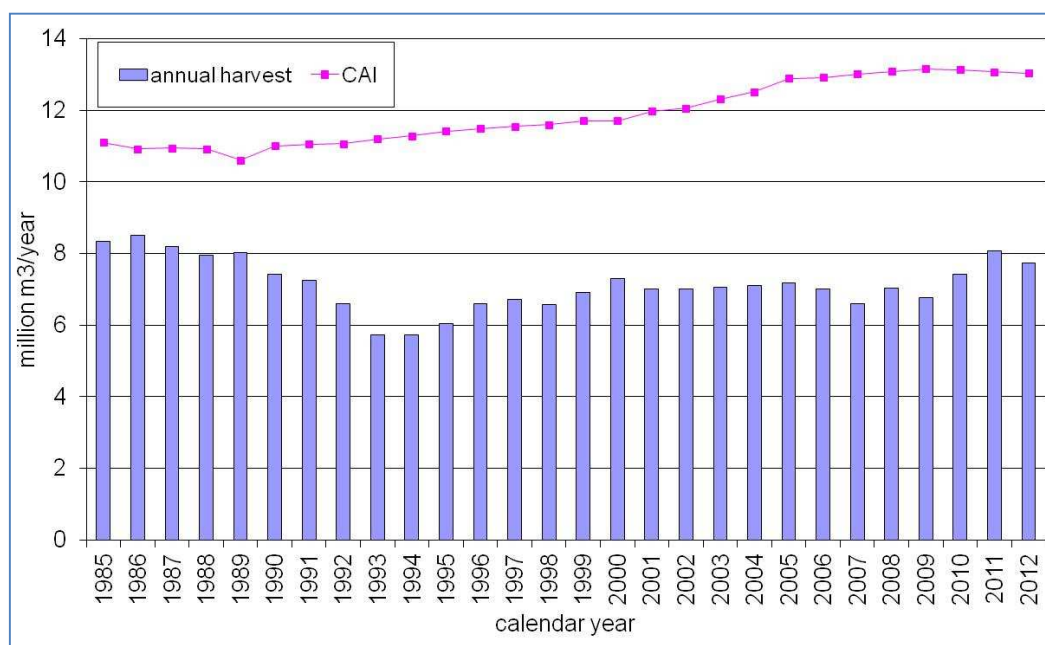
Carbon stock changes of the FL-FL category are calculated from data from other categories. The input data from these categories, together with the formulas used are included in Table 7.3.6. The calculation method used ensures that the stocks of the new FF are excluded from calculating net removals. However, as FF are treated as part of FL-FL, the net removals of all FF are included in the net removals of the FL-FL category. These removals are not estimated specifically from appropriate data from found forests, rather, by using an area specific net removal value (an “implied emission factors”, IEF, of some sort), multiplied by the total area of found forests. The area specific net removal is calculated from the total net removals of all forests and their area.

**Table 7.3.6** Algorithms of calculating carbon stock changes for FL-FL under the UNFCCC, together with sample data for the last few years. For the calculation of emissions and removals from other categories in the table, see the respective sections. The light yellow color in some cells of the table (with column title “from DB”) shows that the data in those cells are taken from the database (i.e., they are the result of other calculations), whereas data in white cells are calculated in this table. NE means net emissions, and IEF means “implied emission factor”.  $\Delta$  is used to denote changes of the value of a land use class between two time points, or changes estimated by using another methodology. All other notations are as in Table 7.3.3. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	ΔC of biomass UNDER THE UNFCCC, GgCO <sub>2</sub>						
	FL	FF, new	FL-L = D <sub>new</sub>	FL	L-FL		FL-FL
	gross Δ	stock	Δ	net Δ = NE	gains	losses	NE
	from DB	from DB	from DB	gross ΔFL - new FF stock - D	from DB	from DB, only for information in this table	net ΔFL - L-FL gains (includes NE of all FF)
2008	-4 992	876	27	-4143	-1 211	4	-2 933
2009	-4 139	981	58	-3216	-1 175	5	-2 041
2010	-3 603	479	28	-3152	-1 157	3	-1 995
2011	-3 566	644	46	-2968	-1 113	3	-1 855
2012	-4 578	871	132	-3838	-1 101	4	-2 737

The resulting carbon stock changes in FL-FL, in combination with those in L-FL (see below) demonstrate (Figure 7.5) that the biomass of the forests in Hungary has been a sink for the last almost three decades. This is also consistent with the fact that the total current annual increment (CAI) for the country has been estimated to be much higher than the annual harvests for all historical years. We also note that the net volume stock changes, and thus the net carbon stock changes display some variability. This, however, is a consequence of the relatively stable CAI estimates and the rather variable harvest estimates. The net of all variability is considered to partly represent true variability. Other parts of the variability, which are related to the varying true increment of the stands, cannot be captured with our estimation system because it is continuous but based on using a combination of measured and model-based (yield tables) estimates. However, we note that the inter-annual variability of the FL-FL carbon stock change estimates is not an artifact, and reflect relatively small

changes in relatively large carbon stocks (these carbon stock changes being, in the last couple of years, less than one percent of the total biomass carbon stocks) even if the forest area does not change much. This is consistent with common forestry experience with single trees and stands, showing largely different net changes (e.g. in annual rings) from year to year.

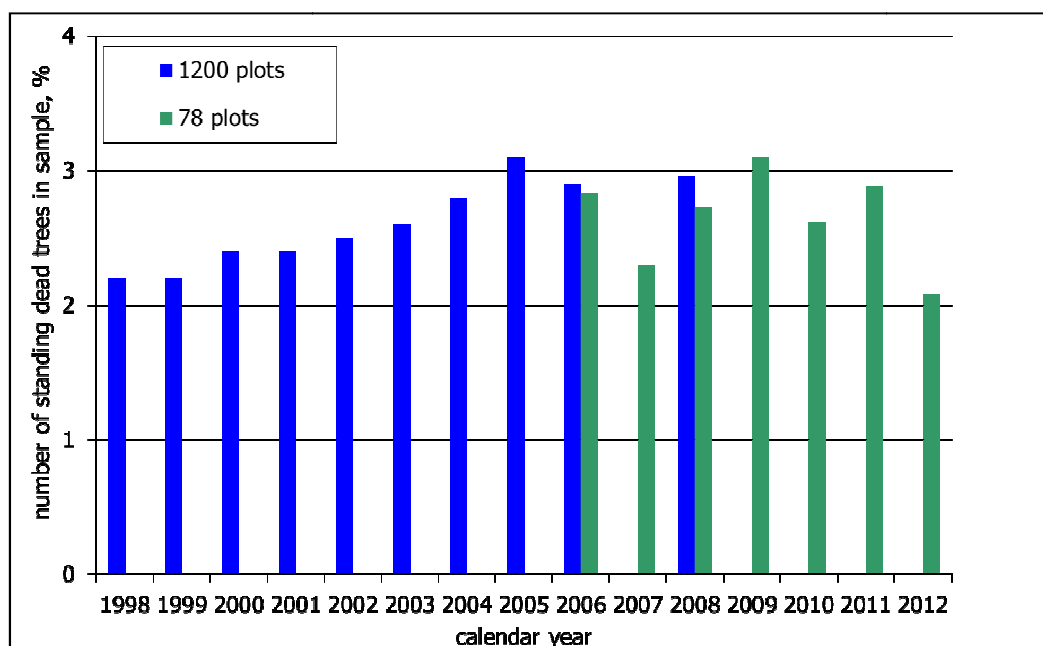


**Figure 7.3.3** Annual harvest and current annual increment (CAI) in Hungary in the last three decades. Data source: National Forest Database.

#### 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 in all stands on 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, but at least that they are not a source.

To demonstrate that the DOM pool is not a source, 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 an (at least) not decreasing trend later (Figure 7.3.4).



**Figure 7.3.4** 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 were 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 7.3.3, 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 as detailed above, 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 clear-cuts were restricted, especially after the adoption of the most recent Forest Act of 2009. This Act requests that semi-natural forests must be managed in an increasingly natural way, which includes leaving more deadwood in the forest after harvests than before, as well as creating and maintaining gaps, and enhancing species mixture. As a result of the implementation of these requirements, we can assume the accumulation of both deadwood and litter in the Hungarian forests.

The other reason of the increase of the dead organic matter and litter in all 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 carbon stocks the dead organic matter pools have not saturated yet.

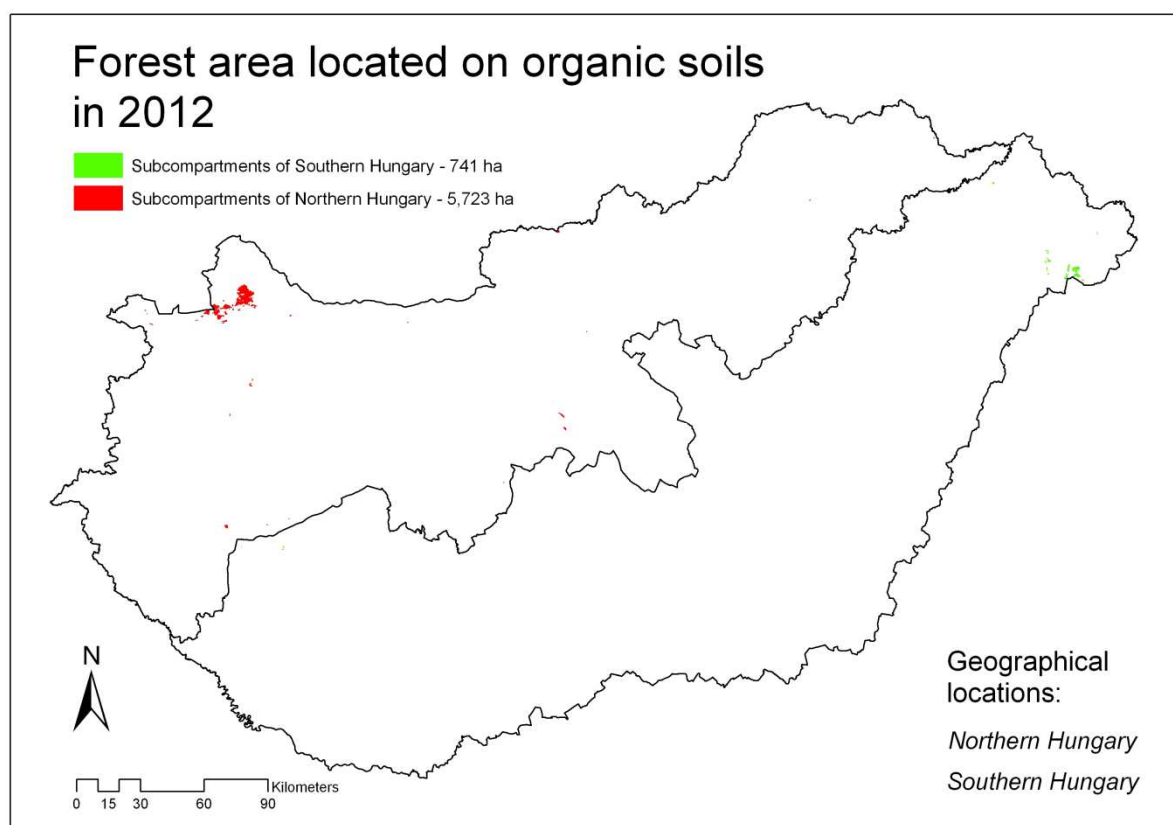
The input of dead organic matter into the soils in turn also increases, even if slowly, the carbon stocks of the soils. Although there are some events that lead to emissions, as we demonstrate it in Chapter 11, soils can also be considered not a source.

Finally, no major disturbances or other processes have occurred that could have resulted in substantial emissions from the above three 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.

With respect to organic soils, we conducted a dedicated project to identify the forest area on organic soils. In this project, we measured the depth and carbon content of various layers in a sample of about 130 stands of an area of about 10 kha where it was suspected that we identify organic soils. The results of the project show that, in fact, the total area of organic soils in the country amounts to 6.46 kha (the distribution of stands of organic soil is demonstrated on Figure 7.3.5). The emissions from these soils, that were typically drained several decades ago, is calculated by multiplying this area by the default IPCC emission factor of  $0.68 \text{ tCO}_2\text{ha}^{-1}$ .



**Figure 7.3.5** The distribution of forest stands of organic soil in Hungary (Illes et al., 2013).

Concerning harvested wood products, changes in the carbon stocks in this pool are not reported (but we plan to report on them beginning next year). The reason for this, in addition to lack of proper data and proper methodology adopted at the moment, 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 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.

### 7.3.1.2.3 CO<sub>2</sub> emissions from liming

In general, emissions from liming cannot be calculated for forestry separately, as only country-wide statistics are available. All emissions from liming in the FL-FL category are therefore reported under the Cropland category. (Note, however, that emissions from liming on deforested land are estimated using a simplified methodology, see in section XXXX.

### 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*) 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 7.3.7 below). Beginning 2012, we apply new factors (Rumpf, 2012) to estimate the amount of slash. The application of new data has become necessary due to some changes in our forestry practice, and has become possible based on additional capacity to provide more accurate estimates than the expert judgment applied before. Additionally, the new study, which was based on expert solicitation, provided new estimates as to the fraction of slash burnt on site, which also changed due to recent changes in legislature on burning in forests. However, we apply the same fraction that oxidized on site as before (0.9). Finally, the IPCC default value was used for the carbon fraction of harvested wood (0.48 tonnes C tonnes biomass<sup>-1</sup> for broadleaves and 0.51 tonnes C tonnes biomass<sup>-1</sup> for conifers). 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. To calculate emissions, 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>.

Wildfires are very erratic in nature, and are not a really significant phenomenon in Hungary. Beginning 1999, the Fire Department started to provide data on the number and area of forest wildfires, however, until 2006, these numbers are not deemed accurate, and the emissions based on these are only rough ones.

In 2006, Hungary joined to the European Forest Fire Information System (EFFIS, <http://effis.jrc.it> or <http://www.jrc.cec.eu.int/>), and a new database was established in the Twinning Project No. HU 2004/016-689.01.02. Thus, beginning 2007, the Fire Department locates the fires, surveys the affected area, and, subsequently, the Forest Authority identifies the affected forest sub-compartments. This identification is done on site, after the fire. The Forest Authority also collects data on how much per cent of the growing stock of each forest sub-compartment was burnt in the fire. (Only crown fires affect the biomass accounted in the GHG inventory, the surface- and ground fires only affect some of the understory vegetation, which is not reported anyway.) 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.

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

With the exclusion of some areas affected by forest fires that are subsequently considered and reported as Deforestation (D), the vast majority of 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 as it is not practicable to report non-CO<sub>2</sub> emissions on L-FL land separately because of its minor contribution to the overall emissions.

**Table 7.3.7** *The amount of controlled burning and forest fires based on all available data.*

Reporting year	Harvested volume (m3)	Slash (t)	Number of wildfires in forest	Burned in forest fires (ha)	Burned in forest fires (m3)
1985	8 345 562	936 929	NE	NE	NE
1986	8 500 991	954 478	NE	NE	NE
1987	8 193 145	918 743	NE	NE	NE
1988	7 960 397	891 281	NE	NE	NE
1989	8 031 779	895 954	NE	NE	NE
1990	7 415 162	824 972	NE	NE	NE
1991	7 255 202	805 380	NE	NE	NE
1992	6 588 569	732 201	NE	NE	NE
1993	5 723 745	634 186	NE	NE	NE
1994	5 717 468	634 392	NE	NE	NE
1995	6 049 151	671 529	NE	NE	NE
1996	6 603 733	732 425	NE	NE	NE
1997	6 713 101	746 015	NE	NE	NE
1998	6 578 931	730 922	NE	NE	NE
1999	6 900 612	766 871	229	756	3 000
2000	7 287 456	812 142	811	1 595	80 000
2001	7 010 979	779 981	419	1 223	57 000
2002	7 013 167	782 245	382	1 226	57 000
2003	7 053 960	790 003	375	1 054	49 000
2004	7 094 753	789 704	104	354	2 000
2005	7 167 426	797 691	150	3 530	170 000
2006	7 005 190	778 736	97	625	3 000
2007	6 609 099	732 709	284	3 471	160 660
2008	7 024 025	780 996	175	731	2 730
2009	6 773 537	752 982	329	2 696	7 000
2010	7 424 046	819 552	69	625	5 324
2011	8 080 206	816 587	2 271	8 548	149 651
2012	7 731 605	785 695	3 108	14 988	120 918

### **7.3.2 Land converted to Forest Land (CRF sector 5.A.2)**

#### **7.3.2.1 Category description**

In Hungary, mainly former croplands are afforested. Converting grasslands to forests is small (about 15% of all conversions), whereas converting wetlands to forests is marginal. Therefore, we report carbon stock changes of converting wetlands to forest land in the other conversion categories.

In general, this category includes areas that do not contain much carbon in either of the carbon pools before they are afforested, but increasing amounts of carbon after the afforestation due to tree growth. Carbon stock changes in lands converted to forests (i.e. afforestations and reforestations) are reported in this category. Currently we only report carbon stock changes in the biomass carbon pool, and as assumptions that, for the entire category, non-biomass pools (i.e., dead wood, litter and soils) are net sinks. This assumption is much more valid for this category than for the FL-FL category (because dead organic matter, that is missing in pre-conversion land, steadily accumulates on all afforested land, see also Section 11), only carbon stock changes in the biomass pools are accounted for.

Concerning soils we note here that, according to recent estimates, whereas converting land from croplands does not entail any net emissions from soil, see Somogyi, (2005), Somogyi-Horváth, (2006a), Somogyi-Horváth, (2006b), and Somogyi et al. (2013). However, there are some indications that converting grassland to forest may lead to some emissions, see Horvath, B. (2006). We are considering reporting these emissions separately. Because However, 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 afforestations 1990-2009, and 858% of afforestations 1990-2012, from survey of NFCSO, Forestry Directorate), so no major emissions from soils are suspected during conversion, thus, we jointly report net carbon stock changes for soils for the entire category. 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 7.3.8 below.

**Table 7.3.8** Area, as well as CO<sub>2</sub> emissions and removals on land converted to forest land.

Inventory year	Total area (ha)	New area (ha)	Outgoing area (ha)	CO <sub>2</sub> gains (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	7 228	-7 476	-1 153
2006	157 561	13 206	-7 496	-1 223
2007	167 556	17 888	-7 892	-1 306
2008	165 994	6 922	-8 484	-1 211
2009	163 588	4 879	-7 285	-1 175
2010	161 905	4 811	-6 494	-1 157
2011	158 202	2 631	-6 334	-1 113
2012	155 647	4 183	-6 739	-1 101

For the period 1985-1989, it was necessary to apply modeling of growing stock, increment and removals of L-FL because, unlike for land under afforestation and reforestation under the Kyoto Protocol (see section 11.3.1.1), the area of L-FL cannot be identified on sub-compartment-level between 1985 and 1989.

In the submission of 2012, the net removals (NR) of L-FL were recalculated for the whole 1985-2010 period by applying, for the first time in reporting, the default 20 years transition period. We continue reporting using this transition period.

The new model is based on the annual 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 NFCSO Forestry Directorate 1985-2012. The data is logged by the Forest Authority and primarily has a subsidy-supporting roll, however, based on a separate study, only 93.9% of this area appears in the National Forest Database as a forest (based on data of 1990-2011).

Table 7.3.9 below demonstrates the evolution of area included in the category. The table shows the area entering the category as new afforestation in the second column. This area is then propagated for 19 additional inventory years, after which the area is moved to the FL-FL category.

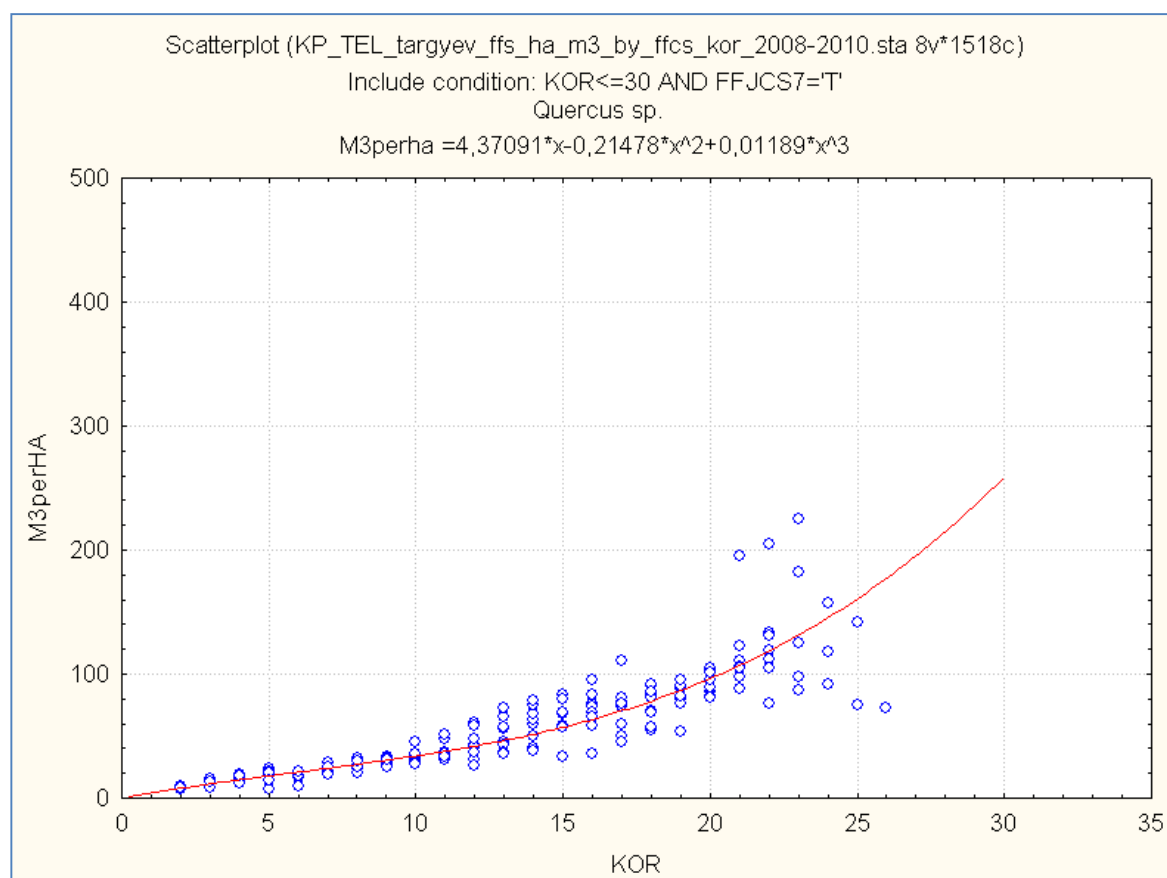
**Table 7.3.9** The area of successfully converted land for all species by year of conversion (blue cells), and total of all converted land in the category (with column) since 1985. Incoming areas are reported in the first year of conversion, and areas reported in the column for conversion year 20 are transferred to the FL-FL category the next year. The total area of the category is not equal to the value reported in the CRF tables, because this table is only for demonstrating how land evolves in the category.

Inventory year	Year of the conversion																				Total area in inventory year (ha)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	Area of successfully converted land (i.a. area actually covered by trees, ha)																				
1985	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1986	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1987	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1988	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1989	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1990	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1991	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1992	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	0	n.a
1993	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	0	n.a
1994	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	0	n.a
1995	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	0	n.a
1996	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	0	n.a
1997	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	0	n.a
1998	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	0	n.a
1999	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	0	n.a
2000	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	0	n.a
2001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	0	n.a
2002	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	0	n.a
2003	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	0	n.a
2004	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	7476	152098
2005	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	7496	151851
2006	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	7892	157561
2007	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	8484	167556
2008	6922	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	7285	165994
2009	4879	6922	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	6494	163588
2010	4811	4879	6922	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	6334	161905
2011	2631	4811	4879	6922	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	6739	158203
2012	4168	2631	4811	4879	6922	17888	13206	7228	7150	11342	14001	12402	9242	8219	7745	7854	6240	3946	2713	3045	155632

In estimating carbon stock changes in these forests, the conversion of volume to carbon happens the same way as described above when discussing the second part of Equation 2.8 of the IPCC 2006 Guidelines (which is a follow-up of equation 3.2.3 of the GPG for LULUCF, IPCC 2003). In order to estimate the volume data in the equation, we have developed a simplified yield table for the young forests over age by a set of regression analyses between ages and volume separately for the above 7 target stand-types (see Figure 7.3.6 is an example of a regression obtained for *Quercus* sp.). This was necessary because, for young individual stands in the category, no accurate height estimates are available that would enable the use of standard yield tables. However, we have age information for all stands as the year of the afforestation is known.

Volume stock is thus estimated based on age information only by classifying stands into age classes (by species) and using age-volume relationships. For the development of these relationships, we created sample sets for the regression analyses. These included age and volume from stands for which we also estimated mean height. For these stands (which were among the stands of the AR category in years 2008-2010), we could estimate volume by using standard yield tables. Then, 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 pole. All regression coefficients are above 0.9, and the regression parameters are significant for each species. Volume stock *change* from a specific year of age to the next year is equal to the *difference* between the volume stocks of the respective consecutive ages. In fact, it is these differences for the various age classes and species that are directly multiplied by the area of the same classes. The resulting changes are thus smoothed ones, not representing any inter-annual variation due to e.g. variation of growing conditions. More importantly, however, the above procedure ensures that the volume stocks

of the respective classes are not applied in the calculations, and no transition of volumes are directly applied from the L-FL category to the FL-FL category when stands are moved to this latter category.



**Figure 7.3.6** An example of regression of age (KOR) and stand volume per hectare (M3perHA). For this fitting, data of *Quercus* sp. (T) afforestations was used. Note that volume data are only used between ages 1 and 20 years.

Concerning the area of the L-FL category, an afforestation activity is deemed to have begun when soil preparation is started. The first (“initial”) planting of the propagation material on the area happens in a short time after soil preparation is done. The total area of the initial planting of all stands (by main target species) is entered into the L-FL category (for each year from 1985 to 2012). Beating up may be carried out depending on the success rate of the initial planting. The area of each stand is then rolled over the 20 years default transition period.

For any inventory year, the area of a species of specific age is multiplied by the annual difference of the volume stocks of the above model for the age of the stand. Total volume stock changes for the category are then derived by summing up the volume stock changes of all stands of all ages (1-20 years) in the category. The methodologies of converting volume to biomass and then carbon stock changes in this category are the same as used in the FL-FL category as described above.

We have also estimated the emissions arising from removing carbon during the conversion from the former land use to forest. According to a new study, the amount of carbon lost by removing all above-ground woody biomass due to conversion for a unit area amounts to 4.7 tC/ha in case of orchards and 8.86 tC/ha in case of vineyards (Juhos és Tőkei, 2013). The amount of total loss of carbon is estimated by multiplying the above values with the size of

the area actually converted. Note that, according to the default method, the pre-conversion below-ground biomass is not considered a loss, and indeed it remains in the ground and adds to the carbon pools of deadwood, litter and soil.

With respect to above-ground 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. We think that our current sampling (and data) is not intensive enough to perform an estimation to report emissions/removals from deadwood, litter and soil. Anyway, we are considering to analyze the numeric model behind the demonstration applied in section 11.3.1.2 to test its applicability in L-FL. In all probability, the conversions of non-forest land to forest land result in net removals in the DOM & soil pools, but we will keep the demonstration as reported and remain conservative, and we consider this also an acceptable approach for L-FL until we develop a more advanced estimation.

#### **7.3.2.3 Methodological issues – non-CO<sub>2</sub> emissions**

In Hungary, very few forest fires occur in the Land converted to Forest Land category. Because it is not practicable to report non-CO<sub>2</sub>-emissions from these fires separately, all of these emissions are estimated and reported under FL-FL(see above).

### 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 any other land use type are generally prohibited by the Forest Act, and can take place only after the Forest Authorities grant permission. All areas of conversions can and are thus be surveyed, and are estimated using the land conversion database of the Forest Authorities (see [https://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/statistics.html](https://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/statistics.html), in Hungarian). 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 calculation of the estimation of emissions from soils.

For further information on deforestation in Hungary, see Section 11.3.1.1.

#### 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, deadwood, litter and soil pools, as well as from liming on deforested land (Table 7.3.10).

**Table 7.3.10** Total emissions from biomass, deadwood, litter and soils. The light yellow color in some cells of the table (with column title “from DB”) shows that the data in those cells are taken from the database (i.e., they are the result of other calculations), whereas data in white cells are calculated in this table. NE means net emissions. All notations as for Tables 7.3.3 and 7.3.6. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	Emissions and removals from FL-L (=D), GgCO <sub>2</sub> eq.				
	biomass, NE	other pools			total
		deadwood	litter	soil	
	from DB	from DB	from DB	from DB	biomass + other
2008	27	3	9	12	51
2009	58	4	15	13	89
2010	28	2	7	12	48
2011	46	2	9	13	70
2012	132	7	25	13	177

For biomass, we follow the same methodology that is detailed in the general section of the sector. 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 separately report emissions from deforestations. In the carbon stock change calculation, we assume that the biomass carbon stock after the conversion is equal to zero, so the total carbon stock of the deforested land that existed as biomass 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  $1/20^{\text{th}}$  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 amounts 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 to get the aggregated emissions.

We note here that the specific emission data (which is a combination of soil reference carbon stock and  $F_1$  factor) were revised earlier due to the reassessment of the cropland land management practices back to 1998, which resulted in a recalculation of the respective historical data.

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). Based on a country-wide classification, this resulted in the distribution of land within conversion types. All deforested land was classified by conversion type and the within-conversion type categories. For each category, 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 7.3.11.

**Table 7.3.11** The area, as well as CO<sub>2</sub> emissions from soils on land converted from forest to other land uses.

Inventory year	FL converted to CL		FL converted to SE		FL converted to GL		All conversions from FL to other land use	
	Area	CO2	Area	CO2	Area	CO2	Area	CO2
	(ha)	emissions (Gg)	(ha)	emissions (Gg)	(ha)	emissions (Gg)	(ha)	emissions (Gg)
1985	94.8	3.563	210.5	7.423	20.9	0	326.1	10.986
1986	94.8	3.563	210.5	7.423	20.9	0	326.1	10.986
1987	94.8	3.563	210.5	7.423	20.9	0	326.1	10.986
1988	94.8	3.563	210.5	7.423	20.9	0	326.1	10.986
1989	94.8	3.563	210.5	7.423	20.9	0	326.1	10.986
1990	180.0	3.723	392.6	7.745	40.3	0	612.9	11.467
1991	59.9	3.657	167.0	7.668	12.9	0	239.8	11.325
1992	44.4	3.563	71.8	7.423	9.4	0	125.6	10.986
1993	12.7	3.408	233.1	7.463	82.7	0	328.6	10.872
1994	28.4	3.284	162.5	7.379	27.3	0	218.2	10.662
1995	53.2	3.205	244.1	7.438	60.5	0	357.8	10.643
1996	78.7	3.175	188.1	7.399	79.0	0	345.9	10.574
1997	192.1	3.358	239.6	7.450	90.3	0	522.0	10.808
1998	88.9	3.344	271.4	7.557	41.7	0	402.0	10.902
1999	26.8	3.215	277.9	7.676	90.7	0	395.4	10.892
2000	67.8	3.161	594.9	8.354	56.4	0	719.1	11.515
2001	61.4	3.095	358.6	8.615	100.9	0	520.9	11.710
2002	108.9	3.115	439.5	9.019	89.2	0	637.5	12.134
2003	25.7	2.983	523.4	9.571	44.1	0	593.3	12.554
2004	74.2	2.939	750.5	10.523	119.1	0	943.8	13.462
2005	71.2	2.889	313.2	10.704	26.7	0	411.1	13.593
2006	44.4	2.790	443.4	11.115	20.8	0	508.6	13.905
2007	16.4	2.641	192.5	11.083	36.6	0	245.5	13.724
2008	97.0	2.638	162.0	10.994	35.0	0	293.8	13.632
2009	56.2	2.560	296.8	11.145	102.7	0	455.0	13.705
2010	59.4	2.326	102.3	10.633	46.6	0	208.3	12.959
2011	67.0	2.331	185.3	10.665	24.2	0	276.5	12.996
2012	113.1	2.445	280.4	11.033	388.9	0	782.4	13.478

Finally, emissions from deadwood and litter are estimated by multiplying the area of annual deforestations by an area-specific value. For more details, see section 11.3.1.1.

### 7.3.3.2 Methodological issues – Non-CO<sub>2</sub> emissions and removals

Non-CO<sub>2</sub> estimation is based on the fact that deforestations in Hungary are done by clear-cutting the areas and removing most biomass from there.

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 7.2.3.

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 (note that as there was a revision of the emission

data as described above, N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland were also recalculated). Using these CO<sub>2</sub> emissions for cropland, we applied Equations 3.3.14 and 3.3.15 of the GPG (IPCC, 2003) to estimate N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland. 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 based on the prioritization of the uncertainty of the estimates 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. In our report of 2010, uncertainty estimation was based on modeling and expert judgment. Beginning 2012, we report new and even more detailed uncertainty estimation for carbon stock changes in the biomass of forests for the categories under the Kyoto Protocol, see Chapter 11 for details (Section 11.3.1.5). As the methods of estimation are similar to respective categories under the UNFCCC, we regard the results reported there relevant for the uncertainties of emissions and removals under the UNFCCC.

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* and precision, the reported estimated values are generally accurate and precise as far as practicable, and are based on the best available data and methods. 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, 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 ("found forests") 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), another is the natural expansion of forest area. Nevertheless, the detection and monitoring of forest area has been continuously improving in the country.

It is also probable that, due to conservativeness built into the methods of the national forest inventory in order to comply with traditional requirements for sustained yield, both volume stocks, and therefore, volume stock changes are underestimated. This assessment is also supported by unofficial statistical results of a sample-based inventory which indicate higher volume stocks and higher volume increment each year than the continuous forest inventory. Finally, wood harvests also seem to be underestimated a bit due to illegal cuttings, which, according to some expert judgments, may account for maximum 250,000 m<sup>3</sup> of harvest annually that is additional to the annual official figure of around 7-8 million m<sup>3</sup>. (This figure, which is used when updating volume stock information, rather variable from year to year). Considering the highly probable underestimation of volume stock increment and the somewhat underestimated wood harvests in combination, volume stock changes are most probably underestimated.

We have continuously been improving not only our stand statistics, but also our country-specific emission factors. As mentioned before, accuracy was improved earlier e.g. by introducing new, more realistic, country-specific based wood density values, slash fraction, soil C/N values and the biomass of orchards and vineyards that have been removed during conversions from cropland to forest land.

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 during the development of the GHG inventory 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 represent 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, estimated values may deviate from actual values as the stock volume inventory for the whole country is not able to capture all inter-annual variability of timber growth and harvests.

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 and precise as far as practicable for the years for which we have data on wildfires and controlled burning. Data collection has improved a lot for most recent years.

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.

### **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 the responsible authorities have been applying computer-based information technology since the early '80-s. The database is updated annually, and the data is checked by many people at subsequent procedures from field assessment to data processing. The constant development of field methods and informatics, improvement of checks, and increasing requirements on the quality of work resulted in increasing accuracy of the Database in recent years.

Since 2011, the GHG inventory has been completed by the National Food Chain Safety Office Forestry Directorate (formal Central Agricultural Office), i.e. the institute that runs the National Forest Database and other mentioned databases.

As a quality assurance, double-checking of the data processing and correct application of IPCC assumptions and methodologies were 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 Meteorological Service, i.e. the

institute responsible for the entire national inventory.

Data verification was, and is continuously conducted concerning activity data (see the comparison of volume stock changes with trends of wood volume increment and harvest, and 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

An error related to the calculation of CO<sub>2</sub> emissions from Deforestation was corrected in 2013, resulting in a tiny difference in emissions (see section 11.3.1.4).

We have started to apply a new, country-specific value for the biomass of orchards and vineyards that have been removed during conversions from cropland to forest land. This has resulted in changing the emission estimate from these conversions, however, as these emissions are rather small, they have a minor effect on the total emission estimates.

New developments (new area estimates) were also introduced in the organic soils category, see the respective section for details. Overall, these developments helped make the inventory more complete and accurate, however, they have not had any considerable effect on the extent of the overall emission and removal estimates.

Finally, as a follow-up to the request by the ERT, we have changed the use of notation keys in the following cases:

Category	Old value	New value
<b>5.A Forest Land/ Forest Land remaining Forest Land/ Forest subcompartments</b>		
Net carbon stock change in DOM	NE	NO
Net carbon stock change in soils/ Mineral soils	NE	NO
<b>5.A Forest Land/ Forest Land remaining Forest Land/ Other subcompartments</b>		
Net carbon stock change in DOM	NE	NO
Net carbon stock change in soils/ Mineral soils	NE	NO
Net carbon stock change in soils/ Organic soils	NE	NO
<b>5.A Forest Land/ Land converted to Forest Land/ Carbon stock change</b>		
<b>5.A.2.1 Cropland converted to Forest Land</b>		
Net carbon stock change in DOM	NE	NO
Net carbon stock change in soils/ Mineral soils	NE	NO
<b>5.A.2.1 Grassland converted to Forest Land</b>		
Net carbon stock change in soils/ Mineral soils	NE	NO
<b>5.A.2.1 Settlements converted to Forest Land</b>		
Net carbon stock change in soils/ Mineral soils	NE	NO

### ***7.3.7 Category-specific planned improvements***

We believe that most of the area identification, as well as estimation of major sources of emissions and removals provide accurate and reliable information. However, we will continue to continue to develop our data collection on found forests and on deadwood. We may have enough data from the Forest Monitoring and Observation Network to develop more advanced estimates in future.

We will also consider to develop estimates for the carbon stock changes in the litter pool in the afforested areas. However, we think that our sampling intensity is not enough yet to perform an estimation to report emissions/removals. Anyway, we are considering the numeric model that we have used for the demonstration that the litter pool is not a source to test its acceptability in L-FL.

Due to the requirements to apply the new IPCC 2006 GL, we are planning to check the methodology applied with the one that will be required from next year on.

## 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 7.2.1). 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 by sub-categories are shown in Table 7.4.1.

**Table 7.4.1 Cropland areas 1985-2012 (1,000 ha)**

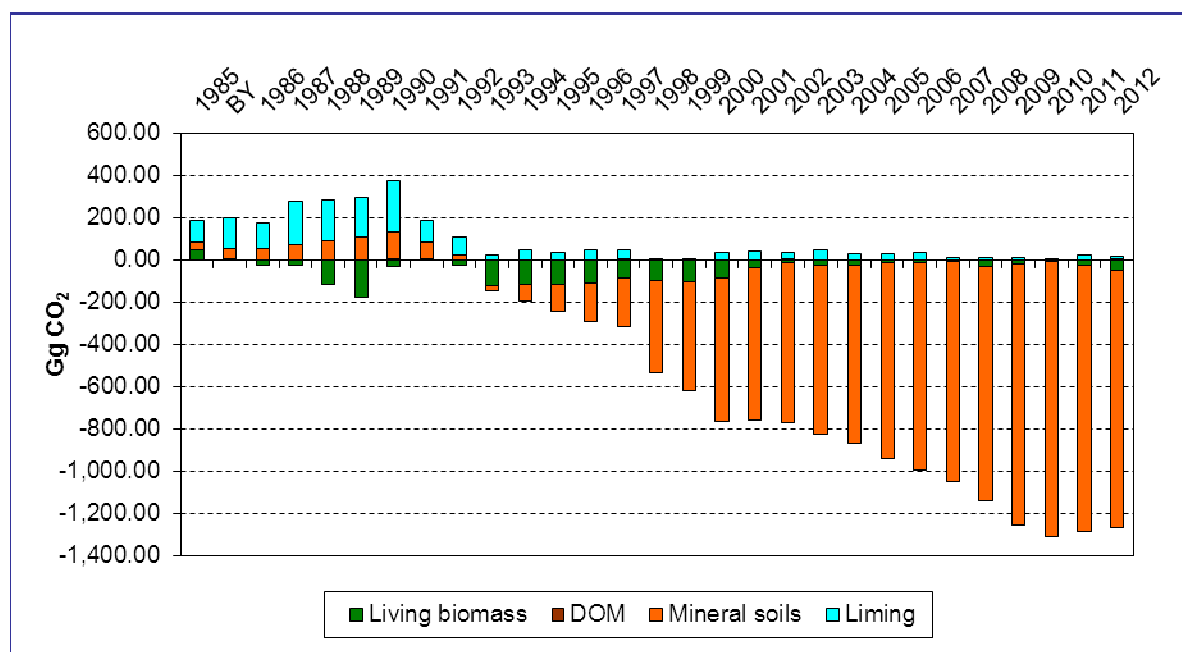
Year	Area [1,000 ha]				Total Cropland
	Annual Cropland <sup>1</sup>	Perennial Cropland		Set-Aside Cropland	
		Orchard	Vineyard		
1985	5,036	104	154	187	5,480
BY	5,042	100	149	182	5,473
1986	5,044	99	147	181	5,471
1987	5,048	97	145	180	5,469
1988	5,050	95	142	180	5,467
1989	5,052	94	140	176	5,463
1990	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
2011	4,404	92	82	640	5,218
2012	4,405	93	82	633	5,212

<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 A3.3).

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 1,252 Gg in 2012, the CH<sub>4</sub> and N<sub>2</sub>O and emission were 0.06 and 0.12 Gg, respectively. Figure 7.4.1 shows the trends in emissions and removals from Croplands by carbon pools over the period 1985-2012.



**Figure 7.4.1** CO<sub>2</sub> emissions/removals from category 5.B Cropland 1985-2012

## 7.4.2 Cropland remaining Cropland

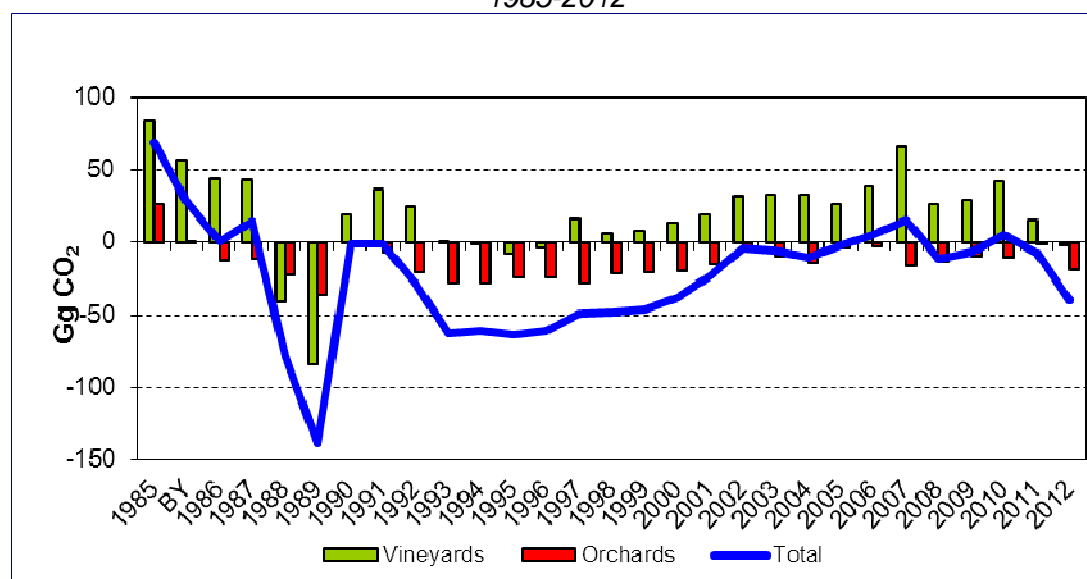
This category comprises emissions and removals from the change of management practices (including the effects of the abandonment) on croplands.

### 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 2012 Cropland living woody biomass in 5.B.1.1 Cropland remaining Cropland was a net sink of 39 Gg CO<sub>2</sub>. The living woody biomass comprises the orchards and vineyards in Hungary.

The total vineyard and orchard areas were a sink of 21 and 18 GgCO<sub>2</sub>, respectively. The average of the annual removal/emissions from Vineyard and Orchard is close to zero throughout the inventory period. The small increase in the area of orchard and the low proportion of the replantation of the vineyard are the reason for this small sink in 2012. It should be noted, removals of orchards and vineyards are reported in the appropriate land conversion categories, in the 5.B.1.1 only the effect of replantation (i.e. biomass cleared to replant with the same crops) is reported. The trend in emissions from the woody biomass total orchards and vineyards areas are shown in Figure 7.4.2.

**Figure 7.4.2** Trends in total emissions/removals from orchards and vineyards 1985-2012



### Choice of method

The carbon stock change in cropland biomass ( $\Delta CC_{LB}$ ) was calculated from the country-specific values of annual rates of biomass gain and loss based on the study of Juhos and Tőkei (2012). A detailed study was conducted on behalf of the Forestry Directorate of the NFCSO to estimate the carbon stocks of vineyard and orchard plantations. In the last decades in Hungary the area of vineyards and orchards decreased significantly and the area of abandoned woody plantations were partly afforested. Therefore the carbon stocks of these woody plantations are not negligible for the estimation of carbon stock changes on afforested cropland areas. On the other hand, the default values for the annual rates of biomass gain and loss provided by the Tier 1 methodology of GPG for LULUCF (IPCC, 2003) seems to be extremely high for Hungary. According to the IPCC default value, 63 tonnes Carbon are stored in the above ground biomass of one hectare woody cropland, while only an average of 49 tC is stored in the living biomass of one hectare forest land in Hungary. Based on the experience and expert judgement of Juhos and Tőkei it is considered that the average carbon stock of the 15-year-old orchards and vineyards are 2.35 and 4.43 tC/ha, respectively. The country-specific loss rates are estimated by taking the IPCC default value of 30 years for the harvest cycle and applying the expert judgement for the 15-year-old carbon stocks to obtain the country-specific carbon stocks at harvest, doubling the 15-year-old carbon stocks. The country-specific value for the accumulation rate was estimated similarly to the IPCC default ones, dividing biomass stocks at harvesting cycle by the time of the rotation period.

Similarly to the Equation 3.2.2 of the GPG for LULUCF (IPCC, 2003) the following formulas were applied to calculate the carbon-stock change in living biomass on perennial croplands:

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

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, tonnes C yr<sup>-1</sup>

$\Delta C_L$ = annual decrease in carbon stocks due to biomass loss, tonnes C yr<sup>-1</sup>

$\Delta C_G = A_G \cdot G$

$\Delta C_L = A_L \cdot L$

Where:

$A_G$  = area of perennial woody cropland (orchard and vineyard in Hungary)

$G$  = county-specific values for orchard and vineyard carbon accumulation rate is 0.16 and 0.3 t C ha<sup>-1</sup> yr<sup>-1</sup>, respectively

$A_L$  = area of cropland on which perennial woody crops (orchard and vineyard) are removed

$L$  = county-specific values orchard and vineyard carbon loss, 4.70 and 8.86 t C ha<sup>-1</sup> yr<sup>-1</sup>, respectively

### 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 A3.3. 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<sub>1985-1990</sub> 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 CO<sub>2</sub> emissions in the 5.B.1 Cropland remaining Cropland category in 2012 was -1,565 GgCO<sub>2</sub>-13 GgCO<sub>2</sub>= -1551 GgCO<sub>2</sub>.

#### 7.4.2.3 Mineral soils

In 2012 mineral soils in category 5.B.1 Cropland remaining Cropland was a sink of 427 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 minor increase in the carbon stock of croplands in Hungary from 1998 (See Figure 7.4.1).

#### Choice of method

For calculation of carbon stock change in mineral soils the IPCC Tier 2 method the Equation 3.3.4. B of the GPG for LULUCF (IPCC, 2003) was applied using country-specific reference soil carbon stocks 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, country-specific

$F_{LU}$  = 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 judgment 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 judgments is detailed in the *Choice of activity data* paragraph below.

The estimated average carbon stocks for Cropland for the period 1965-2012 are shown in Table A3-3.6 of Annex A3.3. (Although the land-use transition is taken into account due to lack of information before 1985. The average carbon stocks are estimated from 1965.)

### *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 A3-3.6 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 had been classified into three soil types from among the types that are determined in the GPG for LULUCF (IPCC, 2003). Classification of croplands by soil types are shown in (Table 7.4.2).

**Table 7.4.2** *Classification of the croplands in Hungary by soil type in proportion to the total land*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	79.38
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 harmonized 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 7.4.3).

**Table 7.4.3** *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
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 7.4.4).

**Table 7.4.4** *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%

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. Statistical data on management practices are not available before 2010 in Hungary. Therefore sales statistics on tools and machines used in reduced tillage supplemented with technological specification on the tillable area were applied as proxy data to estimate the proportion of reduced tillage in the course of the expert judgement. Before 1998 tools and machines for reduced tillage were not available in Hungary at all, hence the reduced tillage is assumed to have been applied in Hungary since 1998.

The replacement of the full-tillage with no-till needs a multi-annual preparation period, therefore 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 and data were extrapolated for 2012.

#### Input

To choose the input factors (Table 7.4.5) 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 44 per cent in 2010.

**Table 7.4.5** *Classification of croplands in Hungary by input in proportion to the total land in 2012*

Input category	Proportion of total cropland area (%)
Low	43.4
Medium	51
High with no manure	5.6

*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 area of cereals - except for maize - is approximately 1.4 million hectares, the proportion of the low input category is significant. We also have to take into consideration that crop residues are typically removed from a certain amount of the area of the crops listed under *medium* input.

*Medium* input cropping systems represent annual cropping with crops where crop residues are returned to the field. This way of growing is characteristic – besides some other less important crops - to maize, sunflower and sugar beet production. These three crops occupy approximately 1.8 million hectares annually. But as it was mentioned earlier, not the total area of these crops can be calculated in the *medium* input category.

*High input (without manure)* rotations are not widely used in Hungary, practically limited to the use of green manures and cover crops. No area was taken into account belonging to the *high input (with manure)* category as regular addition of animal manure is not characteristic to the recent Hungarian agriculture.

#### *Choice of reference soil carbon stocks and stock-change factors*

For the reference carbon stocks ( $SOC_{REF}$ ) country-specific values were applied. The use of country-specific  $SOC_{REF}$  in the Equation 3.3.3 of the GPG (IPCC, 2003) meets the requirement of the Tier 2 methodology for mineral soils.

The country-specific values for the  $SOC_{REF}$  were developed in the course of a research project (Zsembeli et. al, 2013) based on the Hungarian Soil Protection and Monitoring Systems (hereafter referred to as TIM). TIM is an independent subsystem of the Integrated Environmental Information and Monitoring System (KIM). Based on physiographical-soil-ecological units, 877 representative observation points have been selected on agricultural lands. The representative sampling sites were selected by regional soil experts on the basis of all available soil information (profile descriptions, results of laboratory analysis, long-term field observations, maps, etc.) and on their local experiences. The soil carbon stocks of the Hungarian soil types classified into the IPCC ones were determined on the basis of the well known fact that the average carbon content of the organic materials of a soil is 58%. Based on this fact, the following correlation can be established between the humus content and quantity of organic carbon in a soil (FILEP, 1999):

$$Hu\% = organic\ C \times 1.72$$

Where:

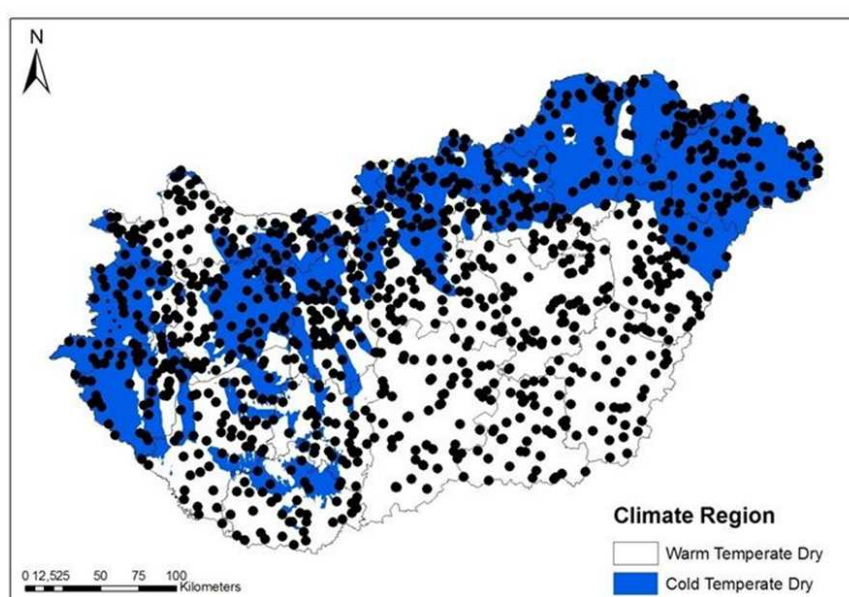
Hu% = humus content of the soil, %

organic C = organic carbon content of the soil, %

The soil carbon stocks of the Hungarian soil types were calculated according to this correlation including the following steps:

1. calculation of the volume of the 0-30 cm deep layer of the soil of the area of 1 ha ( $10,000 \text{ m}^2$ ):  $10,000 \times 0,3 = 3,000 \text{ m}^3$ ,
2. calculation of the mass of this  $3,000 \text{ m}^3$  soil multiplying the volume ( $\text{m}^3$ ) with the average bulk density characteristic for a given soil type ( $\text{g cm}^{-3} = \text{t m}^{-3}$ ):  $3,000 \text{ m}^3 \times m_{\text{tf}}$  ( $\text{t m}^{-3}$ ),
3. calculation of the mass of the humus content of the soil multiplying the soil mass with the humus content percentage:  $m_{\text{tf}} \times \text{Hu}\%$ ,
4. calculation of the carbon content of the humus mass multiplying it with the 0.58 constant:  $m_{\text{tf}} \times \text{Hu}\% \times 0,58$ .

The soil types of the investigated TIM points and the area of the different soil types were determined using the base the AGROTOPO (a Hungarian digital soil map). The Hungarian national soil classification system classifies soils by genetic types; therefore the 79 soil types identified from the TIM and the soil map cannot be allocated to the IPCC soil types directly. The Hungarian genetic soil types were converted into the soil types of the FAO (WRB) soil classification system according to a study (Michéli, 1999), then the FAO soil types were converted to the IPCC soil types using the IPCC soil carbon tools. 14 different WRB soil types were identified, which is corresponded to 3 IPCC soil types (high activity clay soil, sandy soil and aquic soils). The sample plots were also classified into the IPCC climate zones, according to the GPG (IPCC, 2003) based on the climate map of the HMS (Figure 7.4.3). Although it should be noted, that the annual mean temperature in Hungary is about 10 degrees, which is the limit of the IPCC climate zones. It means the difference in the annual mean temperature between the cold and the warm climate zone is only a few tenth of a degree. This resulted that, the soil organic carbon stock for high activity clay soil is higher in the warm climate zones, than in the cold one. The other effects on the soil organic carbon content are more significant than the small difference in the temperature. These other effects arise from the history of soil formation. The warm climate zone in Hungary situated mainly on the Great Hungarian Plain. These low lands along the rivers were inundated almost every spring, before the rivers flows were controlled. (The Danube and Tisza, the main rivers of Hungary have been mostly controlled since the 19th century in Hungary.) The regular flooding resulted in formation of wetlands and high organic content of the soil. The other typical types of vegetation were forest, and forest steppe centuries ago also contributed to the high organic carbon content of the soil. These genetic effects are more dominant on the soil organic carbon content in Hungary than the small difference in the temperature.



**Figure 7.4.3** Sample plots of the Soil Protection and Monitoring System (TIM) by climate zones

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. The stock change factors applied in the Hungarian inventory are shown in, Table 7.4.6, Table 7.4.7, Table 7.4.8 and Table 7.4.9.

**Table 7.4.6** Soil type coverage and soil organic carbon stocks ( $SOC_{REF}$ ) in Hungary (tC ha per ha)

Climate zone	High activity clay soils	Sandy soils	Aquic soils
Cold temperate, dry	48 (50)	15 (34)	166 (87)
Warm temperate, dry	58 (38)	21 (19)	132 (88)

Note: The IPCC default ones are shown in brackets.

**Table 7.4.7** Land use factors ( $F_{LU}$ )

Land use level	Factors
Long term cultivated	0.82
Set aside<20 years	0.93

**Table 7.4.8** Management factors ( $F_{MG}$ )

Land use	Management regime	Factors
Cropland	full till	1.00
	reduced till	1.03
	no-till	1.10

**Table 7.4.9** Input factors( $F_I$ )

Land use	Input of organic matter	Factors
Cropland	low	0.92
	medium	1.00
	high- with no manure	1.07

#### 7.4.2.4 Liming

Liming also showed a decreasing tendency in Hungary in the last decade. Emissions from liming accounted for 13.2 Gg CO<sub>2</sub> in 2012.

#### 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.

### *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 were obtained from the National Plant- and Soil Protection Directorates of the National Food Chain Safety Office (NFCSO). The NFCSO has provided not only the area of the lime application but also the amounts of the lime stone and dolomite use since 2010.

### *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 as well as the TIM database confirm 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. Besides, 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

#### 7.4.3.3 Carbon stock change in living biomass

The carbon stock change in living biomass in category 5.B.2.2 Grassland converted to Cropland amounted to 5.34 Gg C in 2012.

##### *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. ( $C_{\text{After}}=0$ )

##### *Choice of activity data*

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in the CRF Table 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 2000-2006. For years 2007-2011 data available for the last CORINE inventory period is applied. The calculated proportions of annual croplands are 98, 99 and 95 percent for the CORINE inventory periods, respectively. The estimated activity data are presented in Table 7.4.10.

**Table 7.4.10** Activity data of carbon stock change in living biomass in category 5.B.2.2 (ha)

Year	Areas of grassland converted to annual cropland (ha)
1985	4,797
BY	5,596
1986	4,797
1987	7,195
1988	7,195
1989	7,195
1990	7,195
1991	NO

Year	Areas of grassland converted to annual cropland (ha)
1992	NO
1993	8,211
1994	8,211
1995	8,211
1996	8,211
1997	8,211
1998	8,211
1999	8,211
2000	8,211
2001	2,838
2002	2,838
2003	2,838
2004	2,838
2005	2,838
2006	2,838
2007	2,838
2008	2,838
2009	2,838
2010	2,838
2011	2,838
2012	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.

#### *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). 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<sub>AG</sub>= aboveground biomass, tonnes d.m. ha<sup>-1</sup>

B<sub>BG</sub>= 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<sub>AG</sub>) 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.

### *Carbon stock change in soils*

#### **7.4.3.4 Mineral soils**

Carbon stock change in mineral soils in category 5.B.2.2 Grassland converted to Cropland amounted to -93.2 Gg C in 2012.

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  $\text{SOC}_0$  is the *average* soil organic carbon stock of the land-use category in the inventory year (Cropland) and  $\text{SOC}_{0-T}$  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 A3-3.6 and A3-3.7 in Annex A3.3.

#### **7.4.3.5 Wetlands converted to Cropland**

This land-use change is not occurring in Hungary.

#### **7.4.3.6 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 settlements 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.

#### **7.4.3.7 Other Land converted to Cropland**

This land-use change is not occurring in Hungary.

#### **Liming**

No liming was reported for this sub-category.

#### **7.4.3.8 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.

### **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 judgment. The uncertainty

values of the stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003).

In the case of country-specific stock change factors for the perennial woody biomass on cropland a value of 40% suggested by the authors of the study was applied.

The uncertainties of the country specific reference soil carbon stocks were determined from the statistical analysis of the research data using ANOVA (analysis of variance).

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 7.4.11 and Table 7.4.12. In accordance with the GPG (IPCC, 2000) in the case of total uncertainties in the column of the activity data 0, while in the column of the emission factor the total uncertainty was entered. It has to be highlighted that the value of 0 for the uncertainty of activity data could not have resulted in underestimation of the overall uncertainties.

**Table 7.4.11** *Uncertainties in CO<sub>2</sub> removals from 5.B.1 Cropland remaining Cropland by carbon pools*

by carbon pools

Source category	CO <sub>2</sub> emissions/ removals	Uncertainty		
		Area (A)	Stock Change/ Emission factors	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
		u(AD <sub>i</sub> )	u(EF <sub>i</sub> )	
	Gg	±%		
Biomass in 5.B.1				
Gains	-142	6	40	40
Losses	102	30	40	50
Mineral Soils in 5.B.1	-1565	25	88	91
Liming	13	0	25	25
Overall (Liming incl.)	-1,591			90

**Table 7.4.12** *Uncertainties in CO<sub>2</sub> removals from 5.B.2 Land converted to Cropland by carbon pools*

carbon pools

Source category	CO <sub>2</sub> emissions/ removals	Uncertainty		
		Area (A)	Stock Change/ Emission factors	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
		u(AD <sub>i</sub> )	u(EF <sub>i</sub> )	
	Gg	±%		
Biomass in 5.B.2.1	10	21	22	31
Biomass in 5.B.2.2 Gains	-52	30	75	81
Biomass in 5.B.2.2 Losses	32	30	75	81
DOM in 5.B.2.1	5	14	14	20
Mineral Soil in 5.B.2.1	2	5	96	96
Mineral Soil in 5.B.2.2	342	30	88	93
Overall	339			93

### 7.4.5 Category-specific recalculations

Recalculation for 5.B is due to a minor error in the emission calculation spread sheet in relation to the reference carbon stocks of certain types of mineral soils.

As a result of a research project country-specific values have been developed for the reference soil carbon stocks for the 2013 submission. At the same time soils which had been classified as LAC soils in the submissions before that were reclassified as HAC for the previous submission. The change in the carbon stocks arising from the reclassification had not been corrected in all calculation spreadsheets in relation to the reclassified area, resulting in a minor inconsistency, which were corrected for this submission.

The net increase in the CO<sub>2</sub> emissions due to the recalculations in 5.B Cropland category are in the range 1 to 23 Gg (Table 7.4.13).

This recalculations resulted in a negligible change in the N<sub>2</sub>O emissions from the 5(III) ranging from 0.0003 to 0.0081 Gg N<sub>2</sub>O.

**Table 7.4.13** Recalculation of CO<sub>2</sub> emissions from 5.B Cropland 1985-2011

Year	Submission 2013 [Gg CO <sub>2</sub> ]	Submission 2014 [Gg CO <sub>2</sub> ]	Difference [Gg CO <sub>2</sub> ]	Percentage change
BY	198.7	200.8	2.1	1.0%
1985	189.7	190.6	0.9	0.5%
1986	151.5	153.4	1.9	1.3%
1987	255.0	258.3	3.3	1.3%
1988	166.7	171.5	4.7	2.8%
1989	116.4	122.6	6.2	5.3%
1990	340.3	347.9	7.6	2.2%
1991	178.8	186.4	7.6	4.2%
1992	79.7	87.3	7.6	9.5%
1993	-129.2	-120.0	9.2	-7.1%
1994	-154.6	-143.8	10.8	-7.0%
1995	-220.2	-207.8	12.4	-5.6%
1996	-254.5	-240.5	14.0	-5.5%
1997	-282.2	-266.6	15.6	-5.5%
1998	-542.2	-525.0	17.2	-3.2%
1999	-635.3	-616.5	18.8	-3.0%
2000	-744.6	-724.2	20.4	-2.7%
2001	-734.1	-713.1	21.0	-2.9%
2002	-752.0	-730.5	21.5	-2.9%
2003	-801.5	-779.3	22.1	-2.8%
2004	-858.6	-835.9	22.7	-2.6%
2005	-929.0	-906.6	22.3	-2.4%
2006	-983.9	-961.9	22.0	-2.2%
2007	-1,056.6	-1,035.5	21.2	-2.0%
2008	-1,143.4	-1,123.1	20.3	-1.8%
2009	-1,260.4	-1,240.9	19.5	-1.5%
2010	-1,318.1	-1,299.6	18.5	-1.4%
2011	-1,276.0	-1,256.9	19.1	-1.5%

### 7.4.6 Category-specific planned improvements

Main goal is introducing the use of the IPCC 2006 Guidelines in the reporting for the 2015 submission.

..

## 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 758,860 ha remained by 2012 as shown in Table 7.5.1. From the base year the increase of abandoned meadows and pastures were approximately 830%.

**Table 7.5.1 Grassland areas 1985-2012 (ha)**

Year	Area (ha)		
	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
2011	758,874	437,946	1,196,820
2012	758,860	435,642	1,194,502
<b>Trend BY-2012</b>	<b>-39%</b>	<b>826%</b>	<b>-7%</b>

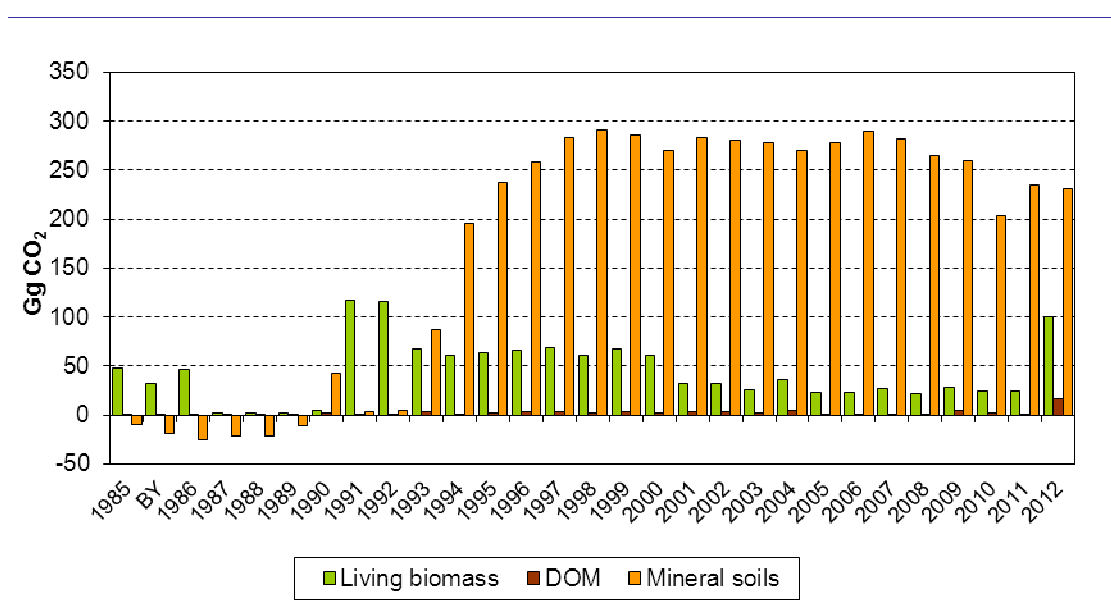
Contrary to this trend, the change in the number of livestock of grazing animals (mainly cattle, sheep and geese as the livestock of horses, water buffalos and goats were not so considerable from the 1970ies) was different. In 1975 more than 2 million cattle, 700 thousand geese and 2 million sheep were 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 7.5.1).

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 net GHG emissions from category 5.C Grassland was 351 Gg in 2012.



**Figure 7.5.1** Trend in emissions/removals from category 5.C Grassland 1985-2012

## 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

Following a recommendation arising from the centralized review conducted in 2012 the reason for reporting 'NO' in the CRF Tables has been corrected as follows.

Grasslands are meadows and pastures which are grazed or harvested annually. Therefore, there is no long term carbon storage in Grasslands. Thus, according to the GPG (IPCC, 2003) the biomass of grasslands is not considered in the estimates. In line with this 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:

$$\Delta C_{GGS\text{Soils}} = \Delta C_{GGM\text{ineral}} - \Delta C_{GGO\text{rganic}} - \Delta C_{GGL\text{ime}}$$

Where:

$\Delta C_{GGS\text{Soils}}$  = annual change in carbon stocks in soils in Grassland remaining Grassland, tonnes C yr<sup>-1</sup>

$\Delta C_{GGM\text{ineral}}$  = annual change in carbon stocks in mineral soils, tonnes C yr<sup>-1</sup>

$\Delta C_{GGO\text{rganic}}$  = annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr<sup>-1</sup>

$\Delta C_{GGL\text{ime}}$  = annual C emissions from agricultural lime application, tonnes C yr<sup>-1</sup>.

$\Delta C_{GGO\text{rganic}}=0$ , because grasslands on organic soils not used for agricultural purposes in Hungary.

$\Delta C_{GGL\text{ime}}=0$ , 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 -63 Gg C in 2012.

### 7.5.2.3 Mineral soils

In 2012 mineral soils in category 5.B.1 Grassland remaining Grassland was a source of 463 Gg CO<sub>2</sub>.

#### *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 A3-3.7 in Annex A3-3.

#### *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 7.4.2.3. 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 7.5.2).

**Table 7.5.2** *Classification of the grasslands in Hungary by soil type in proportion to the total land*

Soil type by IPCC	Proportion (%)
High Activity Clay Mineral	78.26
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 for the period 1985-2000, 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.

HCSO provides data on irrigated grasslands and grasslands treated with chemical fertilizers for some years since 2001. Proportion of the irrigated grasslands is less than 0.1 per cent, therefore the area of grasslands treated with chemical fertilizers is considered to represent improved grasslands in Hungary.

**Table 7.5.3** Grasslands treated with chemical fertilizer

Year	Grasslands treated with chemical fertilizer [ha]
2003	22361
2004	21290
2005	no data
2006	no data
2007	10114
2008	16412
2009	8962
2010	8774
2011	9349
2012	9023

#### 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 Program 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 unfavorable 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 7.5.4** *Classification of grasslands in Hungary by management and input in proportion to the total land in 2012*

Management	Input	Proportion of total grassland area (%)
non-degraded	-	98.81
improved	medium	1.19

#### *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 7.5.2 and Table 7.4.6. 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 7.5.5. The level of input ( $F_I$ ) was assumed to be 1.0 for the improved grassland as well as nominally managed grassland.

**Table 7.5.5** *Management factors ( $F_{MG}$ )*

Land use	Management regime	Factors
Grassland	Nominally managed (non-degraded)	1.00
	Improved	1.14

#### **7.5.2.3.1 Liming**

Liming is not a traditional grassland management practice in Hungary, because the soils of grasslands are not acidic, therefore liming is not required. Statistics of the National Plant- and Soil Protection Directorates of the National Food Chain Safety Office (NFCSSO) also prove this fact. As a consequence in the CRF table 'NO' is reported.

#### *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 Grassland

#### 7.5.3.1 Forest Land converted to Grassland

See Chapter 7.3.3.

#### 7.5.3.2 Cropland converted to Grassland

#### 7.5.3.3 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 4.89 Gg C in 2012.

#### 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>

#### Choice of activity data

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in the CRF Table 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 7.5.6.

**Table 7.5.6** Activity data for carbon stock change in living biomass in category 5.C.2.2

Year	Area (ha)			Total CG
	Annual cropland converted to grassland	Vineyard converted to Grassland	Orchard converted to Grassland	
1985	4271	616	450	5338
BY	2956	373	230	3558
1986	4596	501	240	5338
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0

Year	Area (ha)			Total CG
	Annual cropland converted to grassland	Vineyard converted to Grassland	Orchard converted to Grassland	
1991	15307	448	258	16013
1992	15416	407	190	16013
1993	5404	868	436	6707
1994	5436	834	437	6707
1995	5443	756	508	6707
1996	5451	753	503	6707
1997	5391	853	463	6707
1998	5390	758	560	6707
1999	5377	747	584	6707
2000	5726	555	426	6707
2001	816	561	471	1847
2002	656	616	576	1847
2003	710	612	526	1847
2004	764	608	475	1847
2005	713	571	563	1847
2006	636	623	589	1847
2007	624	747	476	1847
2008	807	557	484	1847
2009	771	561	515	1847
2010	729	617	502	1847
2011	766	487	595	1847
2012	1040	405	403	1847

In the period 1987-1990 the area of total grassland is decreasing significantly, therefore 'cropland converted to grassland' conversions were assumed to be 'NO'.

#### *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  $C_{\text{Before}}$  three different values were applied depending on the biomass. For annual croplands the IPCC default value, given for annual croplands were taken into account ( $5 \text{ tC ha}^{-1}$ ). For orchard and vineyard country-specific values of  $4.70$  and  $8.86 \text{ tC ha}^{-1} \text{ yr}^{-1}$  were applied, respectively. (For more details on country-specific values of loss rates of perennial woody biomass on cropland see chapter 7.4.2.1)

$\Delta C_{\text{Growth}}$  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.)

#### **7.5.3.4 Carbon stock change in soils**

##### *Mineral soils*

Carbon stock change in mineral soils in category 5.C.2.2 Cropland converted to Grassland amounted to  $63 \text{ Gg C}$  in 2012.

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 7.4.2.3) 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 A3-3.6 and A3-3.7 in Annex A3.3.

#### **7.5.3.5 Wetlands converted to Grassland**

This land-use change is not occurring in Hungary.

#### **7.5.3.6 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. For this land-use conversion the IPCC Guidelines do not provide methodology. 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 due to lack of methodology can be considered as a conservative approach, therefore 'NE' is reported for the carbon stock change in the category 5.C.2.4.

#### **7.5.3.7 Other Land converted to Grassland**

This land-use change is not occurring in Hungary.

### **7.5.4 Liming**

In Hungary liming of Grasslands is not occurring; therefore 'NO' is reported in CRF tables. For more details see also section 7.5.2.3.1.

### **7.5.5 Organic soils**

In Hungary no organic soils are under agricultural grassland management therefore 'NO' is reported in CRF tables.

### **7.5.6 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 7.5.7 and Table 7.5.8.

**Table 7.5.7** *Uncertainties in CO<sub>2</sub> removals from 5.C.1 Grassland remaining Grassland*

Source category	CO <sub>2</sub> emissions	Uncertainty		
		Area (A)	Stock Change/ Emission factors	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
		u(AD <sub>i</sub> )	u(EF <sub>i</sub> )	
	Gg	±%		
Mineral Soils	463	25	87	90
Overall	463			90

**Table 7.5.8** *Uncertainties in CO<sub>2</sub> emissions/removals from 5.C.2 Land converted to Grassland*

Source category	CO <sub>2</sub> Emissions/ removals	Uncertainty		
		Area (A)	Stock Change/ Emission factors	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
		u(AD <sub>i</sub> )	u(EF <sub>i</sub> )	
	Gg	±%		
Biomass in 5.C.2.1	83	37	17	41
Biomass in 5.C.2.2 Gains	-21	30	75	81
Biomass in 5.C.2.2 Losses	39	30	75	81
DOM in 5.C.2.1	16	14	14	20
Mineral Soils in 5.C.2.2	-231	30	87	92
Overall	-115			188

### 7.5.7 Category-specific recalculations

Recalculation for 5.C is due to a minor error in the emission calculation spread sheet in relation to the reference carbon stocks of certain types of mineral soils.

As a result of a research project country-specific values have been developed for the reference soil carbon stocks for the 2013 submission. At the same time soils which had been classified as LAC soils in the submissions before that were reclassified as HAC for the previous submission. The change in the carbon stocks arising from the reclassification had not been corrected in all calculation spread sheets in relation to the reclassified area, resulting in a minor inconsistency, which were corrected for this submission.

Changes in the CO<sub>2</sub> emissions from 5.C Grassland are in the range of 2 to 64 Gg. Percentage change in the emissions seems to be more significant due to the low level of emissions in the sector.

**Table 7.5.9** Recalculation of CO<sub>2</sub> emissions from 5.C Grassland 1985-2011

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
BY	11.2	14.0	2.8	20.0%
1985	36.2	38.4	2.2	6.1%
1986	17.9	21.0	3.1	17.3%
1987	-20.4	-17.3	3.1	-15.3%
1988	-20.9	-17.2	3.7	-17.7%
1989	-11.9	-7.6	4.3	-36.1%
1990	43.3	49.2	5.9	13.7%
1991	113.6	121.7	8.1	7.1%
1992	110.7	121.7	11.0	9.9%
1993	145.5	159.0	13.5	9.3%
1994	241.0	257.6	16.6	6.9%
1995	284.9	303.9	19.1	6.7%
1996	307.7	328.0	20.3	6.6%
1997	334.3	356.2	21.9	6.5%
1998	330.7	354.0	23.4	7.1%
1999	331.9	356.3	24.5	7.4%
2000	307.6	332.8	25.2	8.2%
2001	289.5	319.5	30.0	10.4%
2002	281.3	315.6	34.3	12.2%
2003	267.9	306.7	38.8	14.5%
2004	267.8	310.8	43.0	16.1%
2005	257.0	302.4	45.5	17.7%
2006	265.4	314.2	48.9	18.4%
2007	257.6	310.9	53.3	20.7%
2008	232.1	289.2	57.0	24.6%
2009	230.3	291.4	61.2	26.6%
2010	165.4	229.6	64.2	38.9%
2011	197.6	259.6	62.0	31.4%

### 7.5.8 Category-specific planned improvements

Main goal is introducing the use of the IPCC 2006 Guidelines in the reporting for the 2015 submission.

## 7.6 Wetlands (CRF sector 5.D)

### 7.6.1 Description of category

Wetlands account for only 3 per cent of the total area of Hungary (Figure 7.2.1).

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.

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 it has to be stressed that wetlands are precipitation dominated; therefore the extent of wetlands depends on the seasonal and annual variability in precipitation. Thus, the land-use change matrices also could contain natural expansion and shrinking of wetlands.

Nevertheless, emissions from wetlands could not be significant in Hungary because the total Wetlands area did not change remarkably due to human intervention, since wetlands are protected ex lege in Hungary. In addition Hungary is among the signatories of the Ramsar Convention, therefore the preservation and the sustainable uses of Wetlands are emphasized. In 2012, altogether 29 wetlands (259,905 ha) in Hungary had been included in the Ramsar List of Wetlands of International Importance.

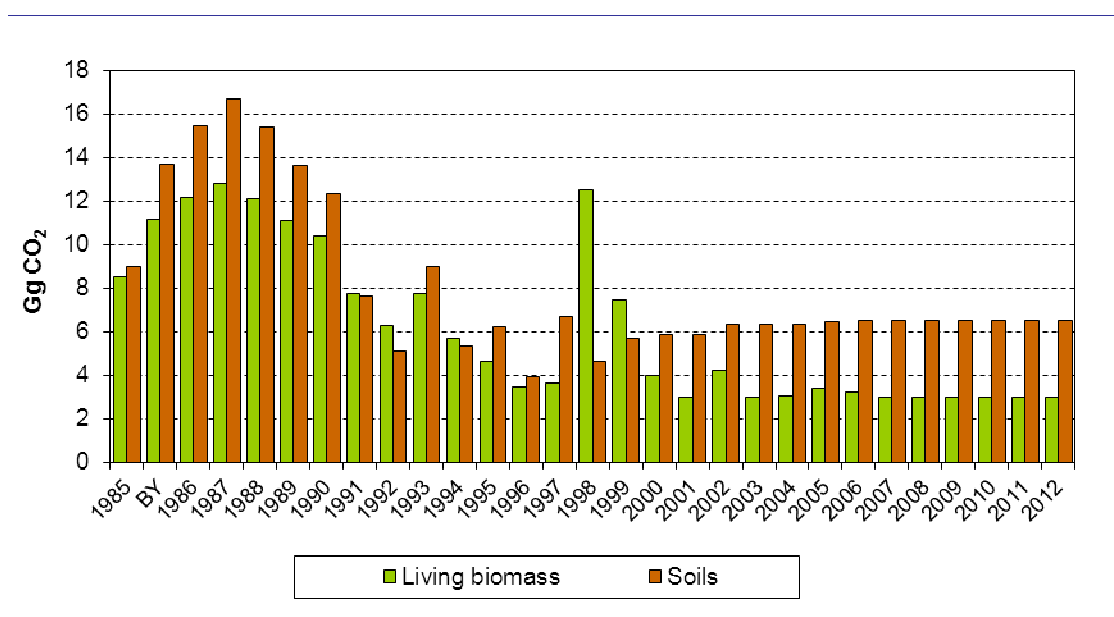
In spite of the low importance of these emissions, to ensure the completeness of the LULUCF inventory and following an encouragement of the annual review conducted in 2013, emissions from peat extraction have been reported for the first time. The Hungarian Mining Authority provided data on the establishment of new peat extraction sites. Although the effect of peat bogs conversion to peat extraction sites seems to be insignificant, because peat mining is a very rare activity due to the strict natural protection law. Since 2006 new extraction sites has not been established at all.

Although further data on conversions to Wetlands is unavailable, in response to a question raised in the course of the EU's quality check for the 2013 submission it was decided to treat the land conversions to water bodies as land conversions to 'flooded land' and report the emissions from these conversions. It is assumed, that lakes are probably forms artificially, as a result of artificial flooding.

As a consequence emissions from living biomass and soil of conversions to peat extraction sites in 5.D.1 Wetlands remaining Wetlands and emissions from living biomass in 5.D.2.3 Grassland converted to Wetlands are reported under 5.D Wetlands. Settlements conversion to water bodies is also traceable in Hungary, but these are construction and mineral extraction sites, which are not covered with living biomass, so cannot be source of emissions.

In 2012 emissions from 5.D amounted to 9.6 Gg CO<sub>2</sub>.

Trends in emissions from 5.D Wetlands by carbon pools are shown in Figure 7.6.1. As it reveals the trends in the emissions is decreasing due to the decreasing area of peat extractions. The relatively higher value of emission from living biomass in 1999 indicates the establishment of a new peat extraction site in Hahót.



**Figure 7.6.1** Trends in emissions from 5.D Wetlands by carbon pools

## 7.6.2 Wetlands remaining Wetlands

This category comprises emissions from land converted to peat extraction, which amounted to 6.5 Gg CO<sub>2</sub> in 2012.

### 7.6.2.1 Carbon stock change in living biomass

Carbon stock change in living biomass from land converted to peat extraction was NO in 2012, because new peat extraction sites was not established in that year.

#### Choice of methodology

Equation 3.5.3 of the GPG for LULUCF (IPCC, 2003) was applied, although both below and above ground biomass was taken into account. According to the IPCC methodology emission from living biomass is reported in the year of conversion.

#### Choice of activity data

Data on areas of land converted annually to peat extraction was received from the Hungarian Mining Authority for the period 1995-2012. For the years 1985 to 1994 data on area conversions are not available, therefore proxy data, namely statistics on peat extraction was used for the estimates.

**Table 7.6.1** Area of land converted annually to peat extraction (ha)

Year	Area of land converted annually to peat extraction (ha)	
	Mire and Peat	Peat
1995	NO	169.32
1996	NO	68.37
1997	12.16	73.87
1998	NO	856.77
1999	203.35	211.97
2000	88.67	28.13

Year	Area of land converted annually to peat extraction (ha)	
	Mire and Peat	Peat
2001	NO	NO
2002	NO	105.45
2003	NO	NO
2004	4.12	NO
2005	NO	34.45
2006	NO	18.53
2007	NO	NO
2008	NO	NO
2009	NO	NO
2010	NO	NO
2011	NO	NO
2012	NO	NO

**Table 7.6.2** Amount of peat extracted (tonnes)

Year	Amount of peat extracted (tonnes)
1985	464
1986	797
1987	860
1988	795
1989	704
1990	637
1991	395
1992	263
1993	464
1994	275
1995	321
1996	202
1997	346
1998	240
1999	313
2000	330
2001	355
2002	341
2003	247

*Choice of emission factors*

In Hungary the typical biomass of peat bogs is grass which was proved in different studies for example (Hubayné, 2005) and (Dömsödy, 2006).

According to the IPCC default values  $-0.5 \cdot (0.41 \cdot 6.5 + 0.59 \cdot 6.1) = -3.13$  tC/ha carbon loss was assumed. (For more details on the resulted carbon loss, see also Section 7.4.3.3)

For the period 1985-1994, for which area data are unavailable an average implied stock change factor (-0.003 GgC/tonnes peat) was estimated, based on the period 1995-2002.

### 7.6.2.2 Carbon stock change in soils

The IPCC Tier 1 methodology was applied, which means that emissions from drainage were estimated using the Equation 3.5.5. To distinguish the areas of nutrient rich and poor organic soils it was assumed that where both mire and peat is extracted the carbon content of the organic soils probably poor while where peat is extracted exclusively high organic content was assumed (Table 7.6.1).

For the period 1985-1994, for which area data are unavailable an average implied stock change factors (-0.18 GgC/tonnes poor peat and -5.11 GgC/tonnes rich peat) were estimated, based on the period 1999-2003.

The carbon stock change in soils due to drainage of organic soils converted to peat extraction amounted to -1.8 Gg C in 2012.

## 7.6.3 Land converted to Wetlands

### 7.6.3.1 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 7.6.3.

**Table 7.6.3** Areas classified as 'Grassland converted to Wetlands'

Period	CLC code	Explanation	Area (ha)
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.

In this category emissions from living biomass of pastures and natural grasslands converted to flooded lands is reported. In accordance with the GPG for LULUCF (IPCC, 2013) carbon stock change in living biomass is reported in this sub-category. In 2012 the emissions from 5.D.2.3 Grassland converted to Wetlands was 3.0 Gg CO<sub>2</sub>

### 7.6.3.2 Carbon stock change in living biomass

The carbon stock change in living biomass in category 5.D.2.3 Grassland converted to Wetlands amounted to -0.8 Gg C in 2012.

#### *Choice of methodology*

Equation 3.6.1 of the GPG for LULUCF (IPCC, 2003) was applied as follows:

$$\Delta C_{LWLB} = A_{\text{Conversion}} \cdot (-C_{\text{Before}})$$

Where:

$\Delta C_{LWLB}$  = Carbon stock change in living biomass due to land-use conversion to Wetlands, tones C year<sup>-1</sup>

$A_{\text{Conversion}}$  = annual area of land converted to Wetlands

$C_{\text{Before}}$  = carbon stocks in living biomass before the conversion to Wetlands, tones C ha<sup>-1</sup>

#### *Choice of activity data*

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in CRF Table, 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 7.6.4.

**Table 7.6.4** Activity data of carbon stock change in living biomass in category 5.D.2.3 (ha)

Year	Areas of Grassland converted to Wetlands (ha)
1985	298
BY	298
1986	298
1987	298
1988	298
1989	298
1990	298
1991	298
1992	298
1993	233
1994	233
1995	233
1996	233
1997	233
1998	233
1999	233
2000	233
2001	263
2002	263
2003	263
2004	263

Year	Areas of Grassland converted to Wetlands (ha)
2005	263
2006	263
2007	263
2008	263
2009	263
2010	263
2011	263

#### *Choice of emission factors*

$C_{\text{Before}}$  was estimated from the IPCC default values according to the distribution by climate zones ( $0.5 \cdot (0.41 \cdot 6.5 + 0.59 \cdot 6.1) = 3.132 \text{ tC ha}^{-1}$ ). For more details see “Grassland converted to Cropland” in Chapter 7.3.

#### **7.6.3.3 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 7.6.5).

**Table 7.6.5** 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 the emissions from these land-use change conversions are probably zero. Due to lack of IPCC methodology for mineral extraction and construction sites these land-use conversion are not estimated and they are currently reported as ‘NE’.

### 7.6.4 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.D are provided in Table 7.6.6.

**Table 7.6.6** *Uncertainties in CO<sub>2</sub> emissions/removals from 5.D. Wetlands*

Source category	CO <sub>2</sub> Emissions	Uncertainty		
		Area (A)	Stock Change/ Emission Factors	Combined, u(AD <sub>i</sub> *EF <sub>i</sub> )
		u(AD <sub>i</sub> )	u(EF <sub>i</sub> )	
		Gg	±%	
	Soils in 5.D.1	7	25	-100/+215 -97/+164
Biomass in 5.D.2.2 Losses	3	50	75	90
Overall	10			-72/+113

### 7.6.5 Category-specific recalculations

CO<sub>2</sub> emissions from lands converted to peat extraction have been included for all years for the first time. Emissions were reported previously as not estimated "NE". This change does not have significant impact on the total LULUCF emissions although the percentage changes seem to be significant due to the low level of emissions from this sector. Emissions increased by 176 per cent in 1996 to 763 per cent in 1987.

**Table 7.6.7** *Recalculation of CO<sub>2</sub> emissions from 5.C Wetlands 1985-2011*

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
BY	3.4	24.9	21.5	627%
1985	3.4	17.5	14.1	411%
1986	3.4	27.6	24.2	707%
1987	3.4	29.5	26.1	763%
1988	3.4	27.6	24.1	705%
1989	3.4	24.8	21.4	624%
1990	3.4	22.8	19.3	565%
1991	3.4	15.4	12.0	350%
1992	3.4	11.4	8.0	233%
1993	2.7	16.8	14.1	526%
1994	2.7	11.0	8.3	312%
1995	2.7	10.8	8.2	305%
1996	2.7	7.4	4.7	176%
1997	2.7	10.4	7.7	288%
1998	2.7	17.2	14.5	542%
1999	2.7	13.2	10.5	392%
2000	2.7	9.9	7.2	271%

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
2001	3.0	8.9	5.9	196%
2002	3.0	10.6	7.5	250%
2003	3.0	9.3	6.3	210%
2004	3.0	9.4	6.4	211%
2005	3.0	9.9	6.9	227%
2006	3.0	9.8	6.8	224%
2007	3.0	9.6	6.5	217%
2008	3.0	9.6	6.5	217%
2009	3.0	9.6	6.5	217%
2010	3.0	9.6	6.5	217%
2011	3.0	9.6	6.5	217%

#### ***7.6.6 Category-specific planned improvements***

Main goal is introducing the use of the IPCC 2006 Guidelines in the reporting for the 2015 submission.

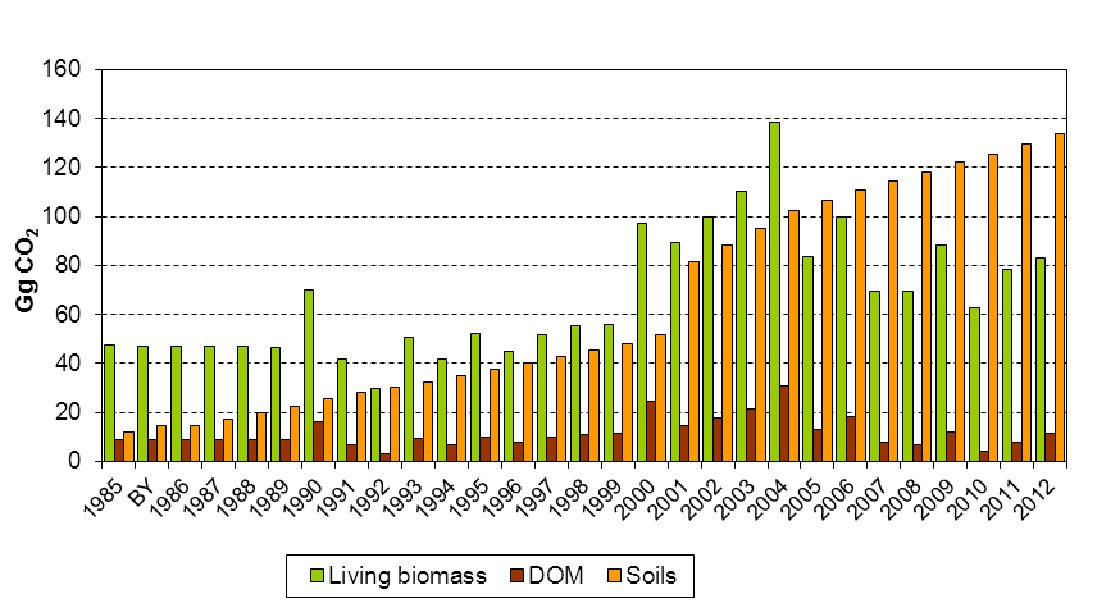
## 7.7 Settlements (CRF sector 5.E)

### 7.7.1 Description of category

Settlements account for 6 per cent of the area of Hungary. In this category only emissions from 'Land converted to Settlements' are reported. 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 A3.3.) 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 and 5.E.2.4 Wetlands converted to Settlements are reported.

Following a recommendation arising from the centralized review conducted in 2013 emissions from 5.E.2.4 Wetlands converted to Settlements have been estimated for the first time.

Emissions due to C stock changes of biomass, DOM and soils on lands converted to settlements amounted to 229 Gg CO<sub>2</sub> in 2012. Trends in emissions from 5.E Settlements by carbon pools are provided in Figure 7.7.1.



**Figure 7.7.1** Trends in emissions from 5.E Settlements by carbon pools

### 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 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 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 areas, which are converted

to settlements are paved over during the conversions, therefore there is not any living biomass after 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  $C_{\text{After}}=0$  and  $\Delta C_{\text{Growth}}=0$ . In the estimation of emissions from mineral soils  $\Delta C_{\text{LSMineral}}=-0.2 \cdot \text{SOC}_0 \cdot A/T$  according to the Guideline (IPCC, 2006).

### 7.7.3.1 Forest land converted to Settlements

See Chapter 7.2.3.

### 7.7.3.2 Cropland converted to Settlements

### 7.7.3.3 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 -10.3 Gg C in 2012.

#### *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

$L_{\text{Conversion}}$  = Carbon stock change per area for the type of conversion when land is converted to

$C_{\text{Before}}$  = carbon stocks in living biomass before the conversion to Settlements, tones C ha<sup>-1</sup>

#### *Choice of activity data*

Activity data used for calculation of carbon stock change in living biomass (Table 7.7.1) are different from those that are provided in the CRF Table, 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 7.7.1** 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	Cropland converted to settlements
1985	705	133	838
BY	734	105	838
1986	746	93	838
1987	750	88	838

Year	Area (ha)		
	Annual cropland converted to settlements	Perennial cropland converted to settlements	Cropland converted to settlements
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
2011	1645	320	1965
2012	1645	320	1965

#### *Choice of emission factors*

For  $C_{\text{Before}}$  in the case of annual croplands the IPCC default value of  $5 \text{ tC ha}^{-1}$  was taken into account, while for orchard and vineyard country-specific values of  $4.70$  and  $8.86 \text{ tC ha}^{-1}\text{yr}^{-1}$  were applied, respectively. (For more details on country-specific values of loss rates of perennial woody biomass on cropland see chapter 7.4.2.1)

#### **7.7.3.4 Carbon stock change in soils**

##### *Mineral soils*

Carbon stock change in mineral soils in category 5.E.2.2 Cropland converted to Settlements amounted to  $-16.4 \text{ Gg C}$  in 2012.

For the details of the estimation of the  $\text{SOC}_0$  of Cropland see Chapter 7.3.

Calculated average carbon stocks of mineral soils for Croplands in Table A3-3.6 and A3-3.7 in Annex A3.3.

#### **7.7.3.5 Grassland converted to Settlements**

#### **7.7.3.6 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  $-1.7 \text{ Gg C}$  in 2012.

*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>

*Choice of activity data*

Activity data used for calculation of carbon stock change in living biomass are different from those that are provided in the CRF Table, 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 7.7.2.

**Table 7.7.2** Activity data of carbon stock change in living biomass in category 5.E.2.3 (ha)

Year	Area of Grassland converted to Settlements
1985	391
BY	391
1986	391
1987	391
1988	391
1989	391
1990	391
1991	391
1992	391
1993	297
1994	297
1995	297
1996	297
1997	297
1998	297
1999	297
2000	297
2001	538
2002	538
2003	538
2004	538
2005	538
2006	538
2007	538
2008	538
2009	538
2010	538
2011	538
2012	538

### Choice of emission factors

$C_{\text{Before}}$  was estimated from the IPCC default values ( $3.13 \text{ tC ha}^{-1}$ ). For more details see “Grassland converted to Cropland” in Chapter 7.3.

### 7.7.3.7 Carbon stock change in soils

#### Mineral soils

Carbon stock change in mineral soils in category 5.E.2.3 Grassland converted to Settlements amounted to  $-6.1 \text{ Gg C}$  in 2012.

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 A3-3.7 in Annex A3.3.

### 7.7.3.8 Wetlands converted to Settlements

HLC\_change and CLC\_change<sub>1990-2000</sub>, CLC\_change<sub>2000-2006</sub> 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 7.7.3** Areas classified as ‘Wetlands 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 construction sites	31
Total			185

As it reveals from the Table 7.7.3 these conversions also contains conversions of water courses and water bodies (Table 7.7.3) which are not covered by soil and living biomass, therefore could not be source of anthropogenic  $\text{CO}_2$  emissions. To improve the completeness of the LULUCF inventory emissions from inland marshes and peat bogs to

sport and leisure facilities, construction sites and road and rail network and associated land have been reported under CRF 5.E.2.4 for the first time in the inventory. These emissions amounted to 40.7 Gg CO<sub>2</sub> in 2012.

### 7.7.3.9 Carbon stock change in living biomass

#### *Choice of methodology*

The biomass of peat bogs and inland marshes is grass (Dömsödi, 2006) since the emissions from living biomass were estimated similarly to the grasslands converted settlements (see also Section 7.7.3.6).

#### *Choice of activity data*

Areas of conversions were estimated based on the annual changes taken from the land-use matrices, while the proportion of inland marshes and peat bogs were calculated based on Table 7.7.3. For the three different periods 20, 23 and 96 percent of the total area of wetland converted to settlements were assumed to be peat bogs and inland marshes, respectively. The estimated activity data are shown in Table 7.7.4.

**Table 7.7.4** Activity data of carbon stock change in living biomass in category 5.E.2.4 (ha)

Year	Area of Wetlands converted to Settlements
1985	3
BY	3
1986	3
1987	3
1988	3
1989	3
1990	3
1991	3
1992	3
1993	2
1994	2
1995	2
1996	2
1997	2
1998	2
1999	2
2000	2
2001	34
2002	34
2003	34
2004	34
2005	34
2006	34
2007	34
2008	34
2009	34
2010	34
2011	34
2012	34

*Choice of emission factors*

$C_{\text{Before}}$  was estimated from the IPCC default values ( $3.13 \text{ tC ha}^{-1}$ ). For more details see "Grassland converted to Cropland" in Chapter 7.3.

**7.7.3.10 Carbon stock change in soils***Organic soils*

Soil of the converted areas was conservatively assumed to be organic due to lack of country-specific data on the carbon-stock of soils of inland marshes and peat bogs.

The GPG for LULUCF (IPCC, 2003) does not provide methodology for land converted to settlements on organic soils, thus the Guideline (IPCC, 2006) was applied.

Converted areas were separated into two different sub-categories, such as 'peat bogs and inland marshes converted to roads and construction sites' and 'inland marshes converted to sports and leisure facilities'. For the period 1985-1992 this distinction cannot be made, therefore the total area of conversions were conservatively considered as conversions to roads and construction sites.

*'Peat bogs and inland marshes converted to roads and construction sites'*

The soil was assumed to be removed, thus the total carbon content of the organic soil was assumed to be released in the year of conversion in line with the Guideline (IPCC, 2006). The carbon content of the removed organic soils was estimated based on the IPCC default value of  $10 \text{ tC/ha/year}$ , which was multiplied by 20, because the carbon release in the year of conversion instead of a 20 year period, resulting a value of  $200 \text{ tC/ha}$  stock-change factor.

The area of conversions was estimated based on the annual land-use change matrices. According to the CORINE database 20, 77 and 96 per cent of the total area of the wetland converted settlements were taken into account for the periods of 1985-1992, 1993-2000 and 2001-2012, respectively.

*'Inland marshes converted to sports and leisure facilities'*

In this case either the biomass or the soil is not removed, therefore only drainage is assumed, and in line with this assumption the IPCC default value of  $10 \text{ tC/ha/year}$  carbon loss was accounted.

The area of conversions was estimated based on the annual land-use change matrices. According to the CORINE database 20, 77 and 96 per cent of the total area of the wetland converted settlements were taken into account for the periods of 1985-1992, 1993-2000 and 2001-2012, respectively. The areas of annual conversions are aggregated for the estimation to get the activity data.

### 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 7.7.5 Uncertainties in 5.E Settlements**

Source Category	CO <sub>2</sub> Emissions	Uncertainty		
		Area (A)	Stock Change/ Emission Factors	Combined, u(ADi*EFi)
	Gg	±%		
Biomass in 5.E.2.1	39	11	17	20
Biomass in 5.E.2.2 Gains	38	30	75	81
Biomass in 5.E.2.3	6	30	75	81
<b>DOM</b>	12	14	14	20
Mineral Soils 5.E.2.1	11	3	96	96
Mineral Soils 5.E.2.2	60	20	88	90
Mineral Soils 5.E.2.3	22	20	87	89
Mineral Soils 5.E.2.4	40	50	90	103
<b>Overall</b>	<b>229</b>			<b>39</b>

### 7.7.5 Category-specific recalculations

There were two reasons for recalculations, which affected the reported CO<sub>2</sub> emissions for the whole time-series.

Firstly, emissions from 5.E.2.4 Wetlands converted to Settlements have been included for the first time. Carbon stock changes in living biomass as well as soils were taken into account.

Secondly, CO<sub>2</sub> emissions from 5.E.2.3 Grassland Converted to Settlements category were revised due to a minor error in the emission calculation spreadsheet in relation to the reference carbon stocks of certain types of mineral soils. As a result of a research project country-specific values have been developed for the reference soil carbon stocks for the 2013 submission. At the same time soils which had been classified as LAC soils in the submissions before that were reclassified as HAC for the previous submission. The change in the carbon stocks arising from the reclassification had not been corrected in all calculation spread sheets in relation to the reclassified area, resulting in a minor inconsistency, which were corrected for this submission.

The inclusion of emissions from 5.E.2.4 had more significant changes, than the revision of 5.E.2.3. However, impact of changes in 5.E on total LULUCF emissions is not significant. Emissions increased by 1 per cent in 2000 to 25 per cent in 2010 under CRF 5.E.

**Table 7.7.6** Recalculation of CO<sub>2</sub> emissions from 5.E Settlements 1985-2011

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
BY	68.5	70.7	2.2	3.2%
1985	66.0	68.2	2.2	3.3%
1986	68.5	70.7	2.2	3.2%
1987	71.1	73.3	2.2	3.1%
1988	73.3	75.5	2.2	3.0%
1989	75.7	78.0	2.2	3.0%
1990	109.4	111.7	2.3	2.1%
1991	74.4	76.7	2.3	3.1%
1992	60.8	63.1	2.3	3.8%
1993	91.2	92.8	1.6	1.8%
1994	81.7	83.4	1.7	2.1%
1995	97.7	99.5	1.8	1.8%
1996	90.9	92.7	1.8	2.0%
1997	102.0	104.0	1.9	1.9%
1998	109.9	111.9	2.0	1.8%
1999	113.6	115.6	2.1	1.8%
2000	170.7	172.9	2.2	1.3%
2001	158.5	185.7	27.2	17.2%
2002	177.6	206.1	28.5	16.0%
2003	197.1	226.9	29.8	15.1%
2004	240.7	271.7	31.0	12.9%
2005	170.9	203.2	32.3	18.9%
2006	195.6	229.1	33.5	17.1%
2007	157.2	191.9	34.8	22.1%
2008	158.3	194.3	36.0	22.8%
2009	185.6	222.9	37.3	20.1%
2010	154.2	192.7	38.5	25.0%
2011	175.6	215.3	39.8	22.6%

### 7.7.6 Category-specific planned improvements

The new CLC-changes2006-2012 databases will probably be available at the end of this year, providing an opportunity to revise the land-use change data as well as land-use-change matrices for the period 2006-2012.

Further refinement of the uncertainty assessment and the development of Monte Carlo approaches are planned for the next inventory cycle.

This submission now includes emissions from 5.E.2.4 Wetlands converted to Settlements for the first time. These emissions were estimated using a conservative approach, consequently the potential emissions are probably highly overestimated, thus further refinement is needed concerning the areas affected by these conversions. As it was outlined in Section 7.6.6 the wetlands areas are planned to be subdivided into inland wetlands and water bodies. In line with this separation the converted areas such as 5.E.2.4 Wetlands converted to Settlements and the related emissions will also be revised.

## **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 7.2.1). 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. Natural grasslands are not under agricultural use therefore they are classified in the land area representation as unmanaged grasslands. In accordance with the chapter 2.2 of GPG for LULUCF (IPCC, 2003) unmanaged grasslands are reported under the 5.C Grassland category.

(Until submission 2010 Hungary reported unmanaged grasslands under 5.F Other Land category, but following the recommendations from the in-county review conducted in 2010 unmanaged-grasslands were reallocated from the 5.F Other Land category into the 5.C Grassland category.)

5. F Other land category includes unmanaged lands exclusively.

As a consequence, emissions from Grasslands converted to Other Land' could not take place on managed land therefore it could not be source of anthropogenic emissions, thus 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 1992-2012.

## 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. 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 0.12 Gg N<sub>2</sub>O in 2012.

As a result of the recalculation of the emissions from mineral soils due to the new country-specific values for reference soil carbon stocks the N<sub>2</sub>O emissions for disturbances has also changed. The effect of this recalculation on the total emissions is negligible due to the low level of emissions from the sector.

### 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 1.8 Gg CH<sub>4</sub> and 0.01 Gg N<sub>2</sub>O in 2011.

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 7.9.1.

**Table 7.9.1** 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 5.A Forest Land category was calculated using the Monte Carlo simulation, which is in accordance with the IPCC Tier 2 methodology. The uncertainties for the other LULUCF sub-sectors have been calculated using the Tier 1, 'simple propagation of error' method provided by the GPG for LULUCF (IPCC, 2003). The Monte Carlo simulation for the other land-use categories is under development. 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 partly on expert judgment, although for certain land-use categories the HCSO has provided uncertainty estimates. The uncertainties of the IPCC default stock change/ emission factors were taken from the GPG for LULUCF (IPCC, 2003), while for the country-specific values statistical calculation or expert judgements are available. In case of 5(IV) the combined uncertainty of the sub-category was estimated because the uncertainties of neither the emission factors nor the activity data were available. In line with the IPCC methodology, 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 -46/+42% in the 2012 inventory. This value is determined largely by the uncertainty in the 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 ( $\pm 188\%$ ) among the land-use categories in the LULUCF inventory. The main driver of the uncertainty in 5.C.2 Land converted to Grassland is the emissions/removals from mineral soils. Net emission from 5.C.2 is the sum of removals and emissions in the same order of magnitude with high uncertainties resulting in a low level of emissions with significantly high uncertainty for the 5.C Grassland 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.

With regard to uncertainties by gas, the CO<sub>2</sub> removals have an uncertainty of -45 / +42 %. 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 7.10.1, Table 7.10.2, 7.10.3 and Table 7.10.4.

**Table 7.10.1** Overall uncertainties in CO<sub>2</sub> emissions/removals from 5.LULUCF by land-use categories

Land-Use Categories	Emissions/ Removals	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub>	%
5.A.1. Forest Land remaining Forest Land	-2,721	-47/+38
5.A.2. Land converted to Forest Land	-1,097	-18/+13
5.B.1. Cropland remaining Cropland	-1,591	±90
5.B.2. Land converted to Cropland	339	±93
5.C.1. Grassland remaining Grassland	463	±90
5.C.2. Land converted to Grassland	-115	±188
5.D.1 Wetlands remaining Wetlands	7	-97/+160
5.D.2 Land converted to Wetlands	3	±90
5.E.2. Land converted to Settlements	229	±39
<b>Overall 5.LULUCF</b>	<b>-4,483</b>	<b>-45/+42</b>

**Table 7.10.2** Overall uncertainties in CH<sub>4</sub> emissions from 5.LULUCF by land-use categories

Land-Use Categories	Emissions	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub> -eq	%
5.A.1. Forest Land remaining Forest Land	31	-29/+163
5.B.1. Cropland remaining Cropland	1	±74
5.C.1. Grassland remaining Grassland	2	±74
<b>Overall 5. LULUCF</b>	<b>34</b>	<b>-27/+148</b>

**Table 7.10.3** Overall uncertainties in N<sub>2</sub>O emissions from 5. LULUCF by land-use categories

Land-Use Categories	Emissions	Combined/Overall Uncertainty of Emissions
	Gg CO <sub>2</sub> -eq	%
5.A.1. Forest Land remaining Forest Land	3	-41/+166
5.B.1 Cropland remaining Cropland	0.3	±74
5.B.2 Land converted to Cropland	38	-100/+74
5.C.1. Grassland remaining Grassland	1	±74
<b>Overall 5. LULUCF</b>	<b>43</b>	<b>-91/+251</b>

**Table 7.10.4** Overall uncertainties in net emissions/removals from 5.LULUCF by land-use categories

Land-Use Categories	Emissions/ Removals	Combined/Overall Uncertainty of Emissions
	CO <sub>2</sub> -eq	%
5.A.1. Forest Land remaining Forest Land	-2,687	-47/+39
5.A.2. Land converted to Forest Land	-1,097	-18/+13
5.B.1. Cropland remaining Cropland	-1,589	±90
5.B.2. Land converted to Cropland	377	±88
5.C.1. Grassland remaining Grassland	466	±90
5.C.2. Land converted to Grassland	-115	±188
5.D.1 Wetlands remaining Wetlands	7	-97/+160
5.D.2 Land converted to Wetlands	3	±90
5.E.2. Land converted to Settlements	229	±39
<b>Overall 5.LULUCF</b>	<b>-4,407</b>	<b>-46/+42</b>

## 7.11 Sector specific QA/QC and verification

Chapter 5.A of the LULUCF inventory as well as the KP-LULUCF inventory are compiled by the National Food Chain Safety Office Forestry Directorate. As a quality assurance, double-checking of the data processing and correct application of IPCC assumptions and methodologies were performed at the national level by the Hungarian Forest Research Institute.

Generally 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 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.

## 7.12 Sector specific recalculation

For this submission revision of soil emissions resulted in the most significant effect on the changes in the emissions, although the overall effect of the recalculations on the aggregate GHG-emissions from the 5. LULUCF sector is not significant. Removals decreased throughout the time-series 1985-2011. The percentage changes of the total emissions in CO<sub>2</sub>-equivalent range from 1.0% to 10.7%. The revised estimates affected the CO<sub>2</sub> as well as the N<sub>2</sub>O emissions because of the calculation methodology of mineralization, which resulted in additional changes in the aggregate GHG-emissions. The changes in CO<sub>2</sub> removals are between 1.0% and 9.4%, while the changes in N<sub>2</sub>O emissions range from 0.3 to 3.7%. The net effect of recalculations is presented in Table 7.12.1

A number of changes were implemented for this submission resulting in the above mentioned decrease in the removals.

Firstly, following the recommendation of ERT (ARR 2012, paragraph 91.) the carbon stock changes in organic soils for the subcategory of forest land is now reported in CRF tables 5.A.1 and KP.B.1.

The project identifying whether some forest land soils can be classified as organic soils in accordance with the IPCC good practice guidance for LULUCF was completed in 2013. The result indicates that there are approx. 6.64 kha forests standing in organic soils in the country.

The C emissions of these stands were calculated using the default emission factor (0.68 t C/ha /year) in accordance with the GPG for LULUCF (IPCC, 2003), and reported under FM.

In CRF table 5.A.1 (Forest Land remaining Forest Land) the area of the forest subcompartments and the 'permanently' unstocked areas were disaggregated following the recommendation of the ERT (ARR 2012, paragraph 88.). This change increases the transparency of the figures in CRF table 5.A but has no effect on the value of the reported emissions.

Following an encouragement and a recommendation from the centralized review conducted in 2013 emissions from both 5.D.1 Wetlands remaining Wetlands/ land converted to peat extraction and 5.E.2.4 Wetlands converted to Settlements have been reported for the first time. Though these additional emissions are insignificant, the inclusions of them were important to improve the completeness of the inventory.

A further reason for the recalculation was the revision of soil emissions to correct an error in the calculation sheet in relation to the reference soil carbon stock of mineral soils.

Reasons for recalculations by land-use categories are as follows:

### 5.A Forest Land

- Including emissions of CO<sub>2</sub> from organic soils for all years for the first time. These emissions were reported previously as not occurring "NO")
- Disaggregation a FL areas under 5.A.1 into 'Forest subcompartments' and 'Others'

### 5.B Cropland

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils

### 5.C Grassland

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils

### 5.D Wetlands

- Emissions from land converted to peat extraction have been reported for the first time;

## 5.E Settlements

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils;
- Emissions from 5.E. Wetlands converted to Settlements have been estimated for the first time.

**Table 7.12.1** *The net effect of recalculations on aggregate GHGs emissions in LULUCF sector*

Year	Submission 2013 [Gg CO <sub>2</sub> -eq]	Submission 2014 [Gg CO <sub>2</sub> -eq]	Difference [Gg CO <sub>2</sub> -eq]	Percentage change
BY	-2,600.3	-2,555.4	44.9	-1.7%
1985	-1,034.4	-998.7	35.7	-3.4%
1986	-3,202.7	-3,155.0	47.7	-1.5%
1987	-3,563.9	-3,512.6	51.3	-1.4%
1988	-3,897.5	-3,846.0	51.4	-1.3%
1989	-2,666.1	-2,615.3	50.9	-1.9%
1990	-2,018.9	-1,966.8	52.1	-2.6%
1991	-2,463.9	-2,417.0	46.9	-1.9%
1992	-3,294.7	-3,248.9	45.8	-1.4%
1993	-5,065.3	-5,009.8	55.5	-1.1%
1994	-5,513.8	-5,459.0	54.7	-1.0%
1995	-5,575.2	-5,516.3	58.9	-1.1%
1996	-1,687.6	-1,629.1	58.5	-3.5%
1997	-1,949.5	-1,884.6	64.9	-3.3%
1998	-3,180.0	-3,104.9	75.1	-2.4%
1999	-1,630.0	-1,556.0	74.0	-4.5%
2000	-682.7	-609.3	73.4	-10.7%
2001	-2,191.0	-2,088.5	102.5	-4.7%
2002	-1,683.4	-1,573.1	110.4	-6.6%
2003	-3,842.6	-3,727.0	115.6	-3.0%
2004	-2,889.7	-2,768.0	121.8	-4.2%
2005	-5,135.0	-5,009.5	125.5	-2.4%
2006	-3,180.7	-3,051.1	129.7	-4.1%
2007	-3,584.5	-3,450.3	134.2	-3.7%
2008	-4,824.5	-4,686.2	138.3	-2.9%
2009	-3,989.8	-3,847.1	142.7	-3.6%
2010	-4,084.7	-3,938.7	146.0	-3.6%
2011	-3,787.5	-3,641.9	145.6	-3.8%

### 7.13 Sector specific planned improvements

Main goal is introducing the use of the IPCC 2006 Guidelines in the reporting for the 2015 submission.

The new CLC-changes2006-2012 databases will probably be available at the end of this year, providing an opportunity to revise the land-use change data as well as land-use-change matrices for the period 2006-2012. The improvements will be implemented depending on the date of the availability of the new database.

## 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) in Hungarian Environmental Report of Hungary (HCSO, 2006)
- Dömsödi, J., (2006): Földhasználat (Land-use). Dialog Campus könyvkiadó, Budapest-Pécs
- 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 poľnohospodárstvu. Michalovce, Slovakia. 64-68.
- Genetic soil types of Hungary (Agrotopo 2000) – soil map
- 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.
- Heil Bálint – Kovács Gábor – Szabó Orsolya, 2012. Szakértői becslés a Kiotói Jegyzőkönyv által előírt éves gázleltár-jelentéshez. NYME research report (in Hungarian), pp. 99.
- Hubayné Horváth, N., (2005): Felhagyott tőzegkitermelő-helyek természeti értékei és hasznosítása. Natural value of cutaway peatlands and their optimal after-use. (in Hungarian with English summary).
- Illés, G. et al. 2013. Jelentés a magyarországi erdőterületeken lévő szerves talajok elterjedésének, szénkészletének és a szénkészlet változását célzó becslések első eredményeiről (Report on the results of estimating the distribution, carbon stock and carbon stock changes of organic soils under forests in Hungary). The project was supported by the National Food Chain Safety Office, Forestry Directorate. Erdészeti Tudományos Intézet, Budapest. In Hungarian.
- Juhos és Tőkei, 2013. A hazai szőlőkben és gyümölcsösökben tárolt szén mennyisége. Report based on a project supported by the National Food Chain Safety Office, Forestry Directorate. Budapesti Corvinus Egyetem Kertészettudományi Kar Talajtan és Vízgazdálkodás Tanszék. In Hungarian.
- 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. Faanyagismeret. Mezőgazdasági Kiadó, Budapest

Michéli, E. (1999): Soil map and classification system of the FAO. In: Talajtan (szerk. Stefanovits, Filep, Fülek), Mezőgazda Kiadó, Budapest, ISBN 963 9239 13 5.

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)

Stefanovits (1999): The humus content of soil. (In Hungarian) In: Talajtan (szerk. Stefanovits, Filep, Fülek), Mezőgazda Kiadó, Budapest, ISBN 963 9239 13 5,

Somogyi Z. (2006): How to demonstrate if a pool is not a source? – case study: forest soils in 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., Bidló, A., Csiha, I., Illés, G., 2013. Carbon balance of forest soils of an entire country: a Hungarian country-specific model based on local case studies. European Journal of Forest Research 132:825-840.

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

Zsembeli et al. (2013): Calculation of organic carbon stocks of the soil types of Hungary on the base of their humus content. (Research report)

## 8. Waste (CRF sector 6)

### Recent key developments:

- In contrast with other sectors, emissions from the waste sector are by 20.8% higher now than in the base year;
- However, the growth in emissions had stopped in the last decade, and a reduction of 9.7% could be observed between 2005 and 2012;
- Amount of disposed municipal waste decreased by 32% between 2005 and 2012;
- Emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

### Major changes from previous submission:

- Reclassification of major part of waste disposal from managed to unmanaged for the years before 2001;
- Introduction of oxidation factor value of 0.1 for well-managed landfills after 2004;
- Minor revision of the time series of disposed waste;

### 8.1 Overview of sector

This section discusses the emissions from municipal solid waste disposal (CH<sub>4</sub>), municipal and industrial wastewater treatment (CH<sub>4</sub> and N<sub>2</sub>O), waste incineration (CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O), and, for the first time, composting (CH<sub>4</sub>, N<sub>2</sub>O). One peculiarity of the sector is that a part of the carbon-dioxide emissions is generated from biological (biogenic) sources and this CO<sub>2</sub> 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 decreased from 1.3 to 1.0-1.1 kg/capita/day in the last few years. The total amount of MSW was 3,987 Gg in 2012. Out of this, 1,015 Gg (25%) was recovered by recycling and composting, 364 Gg (9%) was incinerated for energy purposes, and 2,608 Gg (65%) 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.)

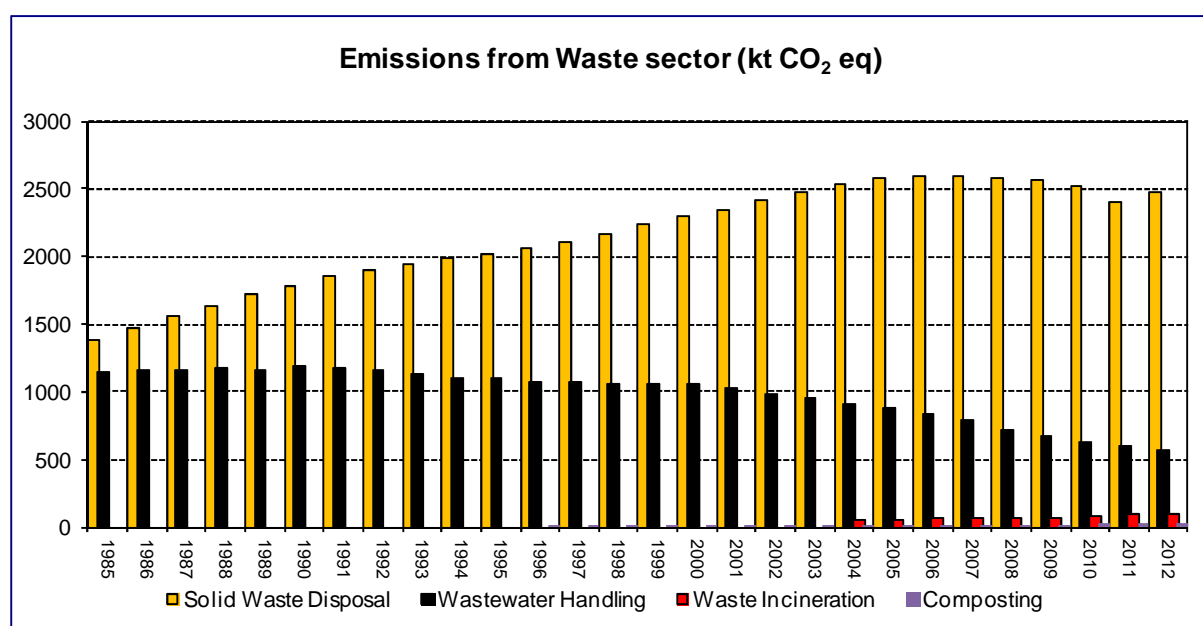
Table 8.1.1 summarizes recent changes in generation and treatment of municipal waste for the period 2005-2012. The following beneficial trends could be observed:

- Increase of waste generation stopped around 2006, and started to decrease quite significantly afterwards (-15% between 2006 and 2012);
- Share of landfilling decreased from 83% to 65% between 2005 and 2012;
- Importance of both recycling and composting increased; currently they represent 21% and 5%, respectively.

**Table 8.1.1** Generation and treatment of municipal solid waste (2005-2012)

	2005	2006	2007	2008	2009	2010	2011	2012
<b>Generated waste</b>	4,646	4,711	4,594	4,553	4,312	4,033	3,809	3,987
<b>Landfilled</b>	3,859	3,792	3,429	3,341	3,212	2,838	2,563	2,608
<b>Incinerated</b>	303	389	382	393	406	406	408	364
<b>Composted</b>	41	58	64	85	90	148	183	183
<b>Recycled</b>	403	432	490	607	576	641	654	832
<b>Other treatment</b>	40	40	229	127	28	0	1	-

The waste sector with 3,176.25 Gg CO<sub>2</sub> equivalent represented 5.1% of total national GHG emissions in 2012. In the base year, total GHG emissions from the waste sector amounted to 2,629,90 Gg CO<sub>2</sub> equivalent which accounted for 2.3% of total national GHG emissions. The largest category was solid waste disposal on land, representing 77.8% in 2012, followed by wastewater handling (18.1%), waste incineration (3.1%), and composting (1.0%). In contrast with other sectors, emissions from the waste sector are by 20.8% higher now than in the base year. However, the growth in emissions had stopped in the last decade, and a reduction of 9.7% could be observed between 2005 and 2012. The degradation process in solid waste disposal sites is quite slow which means that waste that were disposed many years earlier have still an influence on current emission levels. However, the amount of disposed waste had decreased so significantly since 2005 (-33.9%), that methane emissions started to decrease as well. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network. All these developments are summarized in *Figure 8.1.1*.



**Figure 8.1.1** 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.

#### Activity data

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 could be found in statistical publications were for 1975, extrapolation had to be made. For this purpose, a similar pattern as in Figure 8.2.1 had been used. This figure was taken from a university textbook sponsored by the Ministry of Education and Culture.

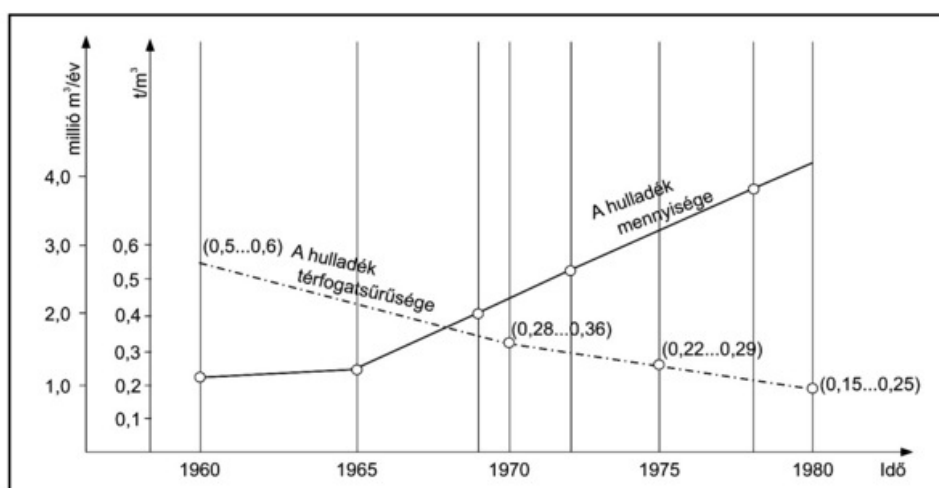


Figure 8.2.1 The loosening trend of municipal solid waste in Budapest. The solid line

*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. 8.2.1*. To summarize the above, the following densities were used for conversion from volume to waste units:

**Table 8.2.1** Waste densities used for conversion

	1975-1985	From 1990	2000
Density ( $\text{t}/\text{m}^3$ )	0.3	0.22	0.2

For the period 1950-1975, instead of using constant values for disposed waste as in previous submission, the following assumptions were made. The first data found in statistical publication was from 1975, i.e. 6,241 thousand  $\text{m}^3$ . This value was converted using a density of  $0.3 \text{ t}/\text{m}^3$  which resulted in a mass value of 1,872 kilotonnes. The IPCC Guidelines suggest using surrogates, e.g. population in cases where domestic data do not cover the last 50 years. In this submission amount of disposed waste between 1950 and 1975 is assumed to be proportional to urban population. Urban population increased by more than 50 per cent between 1950 and 1975 based on information from the statistical office. GDP might have been an alternative but then the increase would have been steeper. (GDP grew by 128 per cent, whereas urban population changed by 31 per cent between 1960 and 1975. A little experiment carried out last year showed, however, that the model is not that sensitive for early years. Even when halving the landfilled amount in 1950, the resulting change in emissions was minus 2% to 3% between 2000 and 2011.)

The next published data for landfilled waste we found was 9,952 thousand  $\text{m}^3$  for 1980. Using the same conversion, this amount is equivalent to 2,986 kilotonnes. For the years between 1975 and 1980, simple interpolation was carried out. The next data was from 1985, i.e. 13,791 thousand  $\text{m}^3$ . Using the same density, it equaled to 4,137 kt from which the incinerated amount (244 kt) was subtracted. Again, an interpolation was made between 1980 and 1985. Then, from 1986, the now *yearly* published statistical data were converted from volume to mass with a diminishing waste density (from  $0.29 \text{ t}/\text{m}^3$  in 1986 to  $0.24 \text{ t}/\text{m}^3$  in 1989).

From 1990, yearly data in mass units published by the central statistical office was used.

From 2006, data from the *Waste Management Information System* maintained by the Ministry of Environment and Water were analyzed and used for calculations. This database 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.

For activity data collection, the main data sources were the following:

- From 1975: Statistical Yearbooks
- 1990-2002: Statistical Yearbooks, Environmental Statistical Yearbooks, Eurostat;
- 2003-2006: Data provision by the Ministry of Environment and Water, Statistical yearbooks, Eurostat
- 2006- Waste Management Information System, Statistical Yearbooks, Eurostat

Beside municipal waste, also industrial waste disposal is taken into account in emission estimations. In the waste information system, disposed waste is categorized by waste types in line with European legislation. Especially the following categories are considered:

- 02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing;
- 03 Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard;
- 04 Wastes from the leather, fur and textile industries;
- 15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified;
- 18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care);
- 20 Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions.

The dominant category is municipal waste (20), the other categories represent additional 2-8 per cent. Therefore, for earlier years, 5 per cent is added to the published statistics of disposed municipal waste to take into account also industrial waste disposal.

In previous submissions, constant methane correction factor of 1.0 valid for well managed landfills was used for the entire time series. This approach could be regarded as overly conservative as it did not take into account the modernization process in solid waste disposal practices and available information on landfill sites. In 2002, a comprehensive survey of landfill sites was carried out with the support of PHARE. During this project, stock was taken of no less than 2,667 landfill sites of which 1,300 were already closed. Out of the operating 1,367 sites, only 42 met current environmental requirements. It was suggested, though, that further 216 sites could operate temporarily till 2009, and the rest should be closed.

One of the outcomes of the project was a database of landfills with several attributes such as depth, volume, insulation, cover etc. The database contained information among others on controlling, lining, compacting, leachate drainage, biogas collection.

Summarizing the data based on total volume of disposed waste (and not on number of landfills), 15% of the disposal could be classified as managed (controlled), 16% as unmanaged shallow, and the remaining 69% as unmanaged deep.

Based on the above information, it didn't seem to be appropriate anymore to allocate all waste disposals to the managed category for the entire time series. Instead, all disposed waste is allocated now to the uncategorized category between 1950 and 1974. For the next period, between 1975 and 2000, the outcome of the above mentioned PHARE project is used, i.e. 85% of the disposed waste is considered as unmanaged (mostly deep), and the remaining 15% as managed. From 2001 on, all disposals are regarded as managed reflecting also the fact that a domestic act on waste management came into force in 2000 (Act No. XLIII of 2000 on waste management).

As a consequence of this new approach, the formerly used parameters, especially the constant MCF value of 1.0 had to be replaced as follows:

- 1950-1974: MCF=0.6 for uncategorized SWDS, OX=0.
- 1975-1985: MCF=0.77 representing 15% managed, 16% unmanaged shallow and 69% unmanaged deep disposal. OX=0.
- 1986-2000: MCF=0.77-0.81 keeping the same share of managed/unmanaged sites but gradually decreasing shallow disposal. OX=0
- 2001-2003 MCF=1.0 OX=0
- 2004- MCF=1.0, OX=0-0.1.

As for the oxidation factor, previously the default zero value was applied for the entire time series. However, it is good practice to use the oxidation value of 0.1 for well-managed landfills. Based on the IPCC GPG, most industrialized countries with well-managed SWDS

use 0.1 for OX, which is a reasonable assumption based on available information.

The Hungarian Waste Information System that serves as our main source of information for activity data from 2004 contains two categories for disposals:

D1 Deposit into or onto land, e.g. landfill

D5 Specially engineered landfill, e.g. placement into lined discrete cells which are capped and isolated from one another and the environment

Landfills categorized as D5 can be regarded as well-managed therefore an oxidation value of 0.1 is justified. The following table shows, how the share of disposal into well-managed landfills increased in the last years.

**Table 8.2.2** *The ratio of managed vs. well-managed landfills*

	D1	D5
2004	50.1%	49.9%
2005	41.8%	58.2%
2006	28.1%	71.9%
2007	35.4%	64.6%
2008	31.4%	68.6%
2009	17.0%	83.0%
2010	3.9%	96.1%
2011	5.0%	95.0%
2012	2.6%	97.4%

#### Other parameters used in calculations

As regards *waste composition*, statistics only exist for the waste collected in Budapest and in good quality only from 1990. Having no other choice, these yearly data were used for the entire country. Again, as the FOD method requires data starting in 1950, further assumptions had to be made. For 1950, the regional default values representative for Eastern Europe were taken from Table 2.3 of the 2006 IPCC Guidelines (i.e. food 30.1%, paper 21.8%, wood 7.5%, textiles 4.7% etc), and interpolation was carried out between these and the measured values for 1980. Details of interpolation can be found in Annex A3.4.

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.

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, and so were the 50% fraction of methane in developed gas and the 6 month of delay time.

**Table 8.2.3** 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>	

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 8.2.4** Summary of activity data and the resulting emissions

YEAR	Disposed MSW [Gg]	Paper [%]	Textile [%]	Decomp. Organic [%]	Hyg.	Recovered methane [Gg]	Emitted methane [Gg]
<b>1950</b>	1,224	22%	5%	30%			
<b>1975</b>	1,872	20%	6%	31%			
<b>Base year</b>	<b>4,018</b>	<b>20%</b>	<b>7%</b>	<b>32%</b>			<b>70.1</b>
<b>1990</b>	3,963	20%	7%	32%			<b>84.9</b>
<b>1991</b>	3,340	18%	3%	38%			<b>88.1</b>
<b>1992</b>	3,506	19%	4%	39%			<b>90.1</b>
<b>1993</b>	3,400	17%	7%	35%			<b>92.5</b>
<b>1994</b>	3,571	18%	5%	33%			<b>94.3</b>
<b>1995</b>	3,655	17%	4%	35%			<b>96.3</b>
<b>1996</b>	3,878	19%	3%	32%			<b>98.3</b>
<b>1997</b>	4,124	19%	6%	28%	4%		<b>100.5</b>
<b>1998</b>	4,133	18%	6%	31%	3%		<b>103.4</b>
<b>1999</b>	4,225	20%	5%	31%	3%		<b>106.4</b>
<b>2000</b>	3,923	14%	4%	41%	1%		<b>109.5</b>
<b>2001</b>	3,881	16%	3%	40%	2%		<b>111.5</b>
<b>2002</b>	4,033	16%	3%	31%	2%		<b>115.3</b>
<b>2003</b>	4,166	16%	3%	30%	3%		<b>118.2</b>
<b>2004</b>	4,050	15%	3%	31%	2%		<b>120.9</b>
<b>2005</b>	4,057	15%	3%	29%	2%	0.0	<b>122.9</b>
<b>2006</b>	3,883	15%	3%	26%	3%	0.9	<b>123.7</b>
<b>2007</b>	3,462	11%	4%	24%	3%	1.7	<b>123.7</b>
<b>2008</b>	3,493	13%	4%	24%	3%	1.7	<b>123.0</b>
<b>2009</b>	3,463	12%	4%	24%	4%	2.4	<b>122.1</b>
<b>2010</b>	2,923	14%	5%	23%	5%	3.9	<b>120.2</b>
<b>2011</b>	2,638	13%	5%	24%	5%	9.2	<b>114.3</b>
<b>2012</b>	2,681	13%	5%	23%	5%	3.8	<b>117.7</b>
<b>Trend</b>	<b>-33.3%</b>	<b>-33.4%</b>	<b>-30.2%</b>	<b>-27.7%</b>			<b>68.0%</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.

*(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).*

### 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. Data from different sources are compared. Our most detailed data source is the Waste Management Information System (HIR) maintained now by the Ministry of Rural Development. This contains among others data on amount, type, consistency, management practices, mode of treatment. Converting these data to an Excel file, we get about 16,000 rows for one year. After analyzing these data, comparisons are made with the aggregated data published by the Hungarian Statistical Office, and also by EUROSTAT. Should we detect any problem, both the statistical office and the ministry can be contacted. The calculations with the IPCC Waste Spreadsheet Model have been saved and archived for future reviews.

### 8.2.5 Recalculation

To summarize the above, our estimates have been changed due to

- Revision of the time series of disposed waste (probably small effect);
- Reallocation of disposal from managed to unmanaged before 2000 (largest effect on emission level);
- Introduction of oxidation factor value of 0.1 for well-managed landfills.

As currently it is not possible to change the OX value year by year in the IPCC Waste model, we did practically the following. Instead of one, we ran four instances of the IPCC Waste Model, i.e. for shallow and deep unmanaged sites, for managed sites with OX=0 and OX=0.1, and then summed up the results of the four.

The overall effects of the recalculations can be seen in the table below. On average, disposed waste increased by 0.9 per cent, whereas the emissions decreased by 19.4 per cent.

	DEPOSITED WASTE (Gg)			CH4 EMISSIONS (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
<b>1985</b>	3893	3893	0.0%	87.30	66.12	-24.3%
<b>1985-87</b>	4018	4018	0.0%	91.30	70.06	-23.3%
<b>1986</b>	4039	4039	0.0%	91.20	70.03	-23.2%
<b>1987</b>	4121	4121	0.0%	95.50	74.03	-22.5%
<b>1988</b>	4102	4102	0.0%	99.70	78.00	-21.8%
<b>1989</b>	3832	3832	0.0%	104.00	81.75	-21.4%
<b>1990</b>	3963	3963	0.0%	107.80	84.88	-21.3%
<b>1991</b>	3340	3340	0.0%	112.00	88.11	-21.3%
<b>1992</b>	3506	3506	0.0%	114.52	90.10	-21.3%
<b>1993</b>	3400	3400	0.0%	117.61	92.55	-21.3%
<b>1994</b>	3571	3571	0.0%	119.84	94.35	-21.3%
<b>1995</b>	3576	3655	2.2%	122.28	96.33	-21.2%
<b>1996</b>	3788	3878	2.4%	124.48	98.28	-21.1%
<b>1997</b>	4023	4124	2.5%	127.00	100.51	-20.9%
<b>1998</b>	4067	4133	1.6%	130.28	103.40	-20.6%
<b>1999</b>	4146	4225	1.9%	133.69	106.35	-20.4%
<b>2000</b>	3847	3923	2.0%	137.27	109.49	-20.2%
<b>2001</b>	3821	3881	1.6%	139.44	111.49	-20.0%
<b>2002</b>	3907	4033	3.2%	141.80	115.28	-18.7%
<b>2003</b>	3966	4166	5.0%	143.20	118.17	-17.5%
<b>2004</b>	3978	4050	1.8%	144.42	120.94	-16.3%
<b>2005</b>	4072	4057	-0.4%	145.52	122.89	-15.6%
<b>2006</b>	3902	3883	-0.5%	145.58	123.66	-15.1%
<b>2007</b>	3477	3462	-0.5%	145.27	123.68	-14.9%
<b>2008</b>	3494	3493	0.0%	143.96	122.95	-14.6%
<b>2009</b>	3439	3463	0.7%	142.48	122.10	-14.3%
<b>2010</b>	2875	2923	1.7%	139.90	120.19	-14.1%
<b>2011</b>	2639	2638	0.0%	132.97	114.34	-14.0%
<b>AVG</b>			<b>0.9%</b>			<b>-19.4%</b>

### 8.2.6 Planned improvements

It is planned to continue data collection on flaring.

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

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

Key source: CH<sub>4</sub>: Level 1, N<sub>2</sub>O: Level2, Trend2

#### 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. Methane emissions from wastewater treatment were calculated using partly basic statistical data, partly very detailed facility level information on wastewater discharge together with the specific emission factors recommended by the 2006 IPCC Guidelines. In our opinion, the 2006 IPCC Guidelines are not in contradiction with the Revised 1996 IPCC Guidelines or the Good Practice Guidance, but present on the one hand more recent knowledge, and more importantly, provide default MCF values for quite a few types of wastewater treatment. For recent years, 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, the inventory compilers consulted with experts, visited a few wastewater plants and checked the calculations of the neighboring countries as well.

##### Activity data

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.

Previously, 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.

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. Moreover, the previously used organic waste content of discharged wastewater related often to values *after treatment* of wastewater. 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 (i.e. 1.5-5.0 kg COD/m<sup>3</sup>), paper and pulp (9.0 kg COD/m<sup>3</sup>), chemical industry (1.0-3.0 kg COD/m<sup>3</sup>). By estimating original organic waste content, reported discharged COD values were taken into account for no treatment or only mechanical treatment, and default COD/m<sup>3</sup> values were used for biological or advanced treatment. The difference between the revised and the previously used activity data was in some cases as big as an order of magnitude. For the first part of the time series

average DC/unit wastewater of 1.16 Gg COD/million m<sup>3</sup> is used to increase consistency of the time series.

The compiler institute has now direct access to the wastewater information system, therefore more detailed data are available to refine the calculations. Thus, BOD5 and COD content of the discharged wastewater reported by wastewater treatment plants and industrial facilities can be taken into account. About 1500 emission reports per year could be analyzed for the period 2005-2012. The following conclusions could be drawn:

- Recently, 150 to 210 million cubic meter wastewater from industrial facilities was discharged into rivers and seas. In 2012, a bit more than half of this amount had either no treatment or only mechanical treatment beforehand.
- The average COD content of the above, only partially treated wastewater was as low as 0.05 kg/m<sup>3</sup>.
- About 20 to 25 million m<sup>3</sup> industrial wastewater was collected via the public sewerage system, and treated in centralized plants, consequently domestic and industrial wastewater treatment could not be separated entirely. Around 80% of this amount went into the public sewerage system after at least biological treatment.
- The average COD content of the above, mostly treated industrial wastewater was definitely higher with 0.6 to 0.8 kg/m<sup>3</sup> in 2008-2012.
- Based on facility level data, it turned out that the previously used COD value per wastewater output in the pulp and paper industry (9 kg COD/m<sup>3</sup>) was too high, and the country specific value of 3.2 kg COD/m<sup>3</sup> seemed to be more realistic.

**Table 8.3.1 Industrial wastewater output in 2012**

2012		m3	COD/m3	kg COD
Iron and Steel		45,476,010	0.03	1,350,017
Non-ferrous metals		2,103,683	0.06	116,614
Fertiliser		13,844,660	0.23	3,184,272
Food and Beverage		65,535,125	0.46	29,942,275
	Beer	1,703,650	2.62	4,462,537
	Wine	17,194	1.50	25,791
	Meatpacking	5,584,141	1.63	9,097,476
	Dairy products	2,702,117	1.51	4,080,864
	Sugar	1,418,615	1.08	1,534,451
	Fish processing	49,535,415	0.05	2,300,474
	Oil and grease	146,279	1.66	242,897
	Soft drinks	701,623	2.71	1,899,680
	Other+vegetables	3,726,092	1.69	6,298,105
Paper and Pulp		6,728,304	3.25	21,900,000
Petroleum refining/Petrochemichals		9,219,720	1.00	9,219,720
Rubber		492,513	0.04	19,724
Other agricultural		5,698,219	0.35	1,984,359
Chemical production		19,496,761	0.43	8,360,486
Other*		24,125,028	0.30	7,175,299
TOTAL		192,720,023	0.43	83,252,765
CRF		192,720,023	0.43	83.25

- Domestic and commercial wastewater treatment plants, (that also treat industrial wastewater), discharge yearly 440 to 580 million m<sup>3</sup> into open water.
- The share of the collected wastewater treated at least biologically or at more advanced treatment plants increased from 35% in 1990 to 66% in 2005, and to 98% in 2012.

- In line with the above development, the average BOD5 content of the discharged wastewater decreased from 0.15 kg/m<sup>3</sup> in 2005 to 0.02 kg/m<sup>3</sup> in 2012.

**Table 8.3.2** Municipal waste water discharge and treatment (1990–) [1000 m<sup>3</sup>]

Year	Total volume of waste water discharge	Volume of treated waste water			Total volume of treated waste water
		only with mechanical treatment	with biological treatment too	with advanced treatment too	
1990	877,187	475,968	280,426	22,979	779,373
1991	826,978	450,224	267,869	21,340	739,433
1992	787,879	449,544	244,066	19,667	713,278
1993	709,786	389,484	236,192	19,162	644,838
1994	652,960	344,383	235,859	13,536	593,778
1995	639,697	325,451	244,992	13,001	583,444
1996	608,372	265,888	239,665	15,431	520,984
1997	570,615	231,634	245,386	11,762	488,782
1998	549,843	222,593	232,777	32,400	487,769
1999	588,460	224,673	261,597	36,998	523,269
2000	530,484	168,910	252,978	57,304	479,192
2001	519,549	197,629	222,229	60,355	480,214
2002	525,179	185,064	214,865	91,738	491,667
2003	525,082	142,451	182,455	163,383	488,288
2004	557,456	165,074	193,404	177,357	535,835
2005	588,064	174,815	188,779	196,784	560,378
2006	567,303	152,939	249,641	133,379	535,959
2007	533,889	128,143	217,654	165,186	510,983
2008	542,106	135,845	204,820	179,123	519,787
2009	529,022	123,512	201,941	182,073	507,525
2010	555,629	17,607	280,760	255,008	553,375
2011	467,594	8,930	219,184	237,848	465,963
2012	435,747	859	111,270	317,283	429,411

Source: Hungarian Central Statistical Office:

[http://www.ksh.hu/docs/eng/xstadat/xstadat\\_annual/i\\_uw005.html](http://www.ksh.hu/docs/eng/xstadat/xstadat_annual/i_uw005.html)

#### Emission factors

For the calculation of the *emission factor* (EF), 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. To calculate the weighted average of MCF, additional information was collected on the share of population with no connection to the public sewerage system. 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 41% now it's around 78%. It must be noted, however, that the percentage of dwellings connected to public sewerage network is still below the Central-European average.
- As a refinement of the above, for those dwellings where neither public nor domestic sewerage exists and probably latrines are used, MCF=0.1 was used in accordance

with the above referenced table from the 2006 Guidelines.

- The share of population connected or not connected to a sewerage system was estimated based on *occupied* dwellings.
- Usually, collected wastewater undergoes aerobic treatment in treatment plants. Default MCF for centralized, aerobic treatment plant is zero. (Table 6.3 in the 2006 Guidelines) Still, MCF values decreasing from 0.1 (in 1985-1995) to 0.05 (in 2005) were used to use the whole range of the default MCF factor from the 2006 Guidelines, thus to allow some emissions in case of incidental overload, and more importantly, to reflect modernization in the sector.
- For years (i.e. 2006-2012), where BOD or COD contents of the discharged wastewater from treatment plants into open waters were available, these values were used with the corresponding maximum methane producing capacity and an MCF value of 0.1 representative of sea, river, and lake discharge.

All the above considerations, used parameters and the resulting emissions are summarized in *Table 8.3.3*.

**Table 8.3.3** Domestic and commercial wastewater treatment (1985-2011)

Year	BOD (Gg)	Share (%)			MCF			Emissions Gg CH <sub>4</sub>		
		Public Sew.	Domest. Sew.	Latrines	Public Sew.	Domest. Sew.	Latrines	Public Sew.	Domest. Sew.	Latrines
1985	232.12	41%	36%	23%	0.10	0.5	0.1	5.65	25.09	3.26
1985-87	231.18	41%	37%	22%	0.10	0.5	0.1	5.72	25.69	3.01
1986	231.26	41%	37%	22%	0.10	0.5	0.1	5.72	25.70	3.01
1987	230.15	42%	38%	20%	0.10	0.5	0.1	5.79	26.28	2.76
1988	229.16	43%	39%	18%	0.10	0.5	0.1	5.87	26.86	2.51
1989	228.22	43%	38%	20%	0.10	0.5	0.1	5.94	26.06	2.74
1990	227.21	44%	41%	15%	0.10	0.5	0.1	6.01	28.01	2.02
1991	227.17	45%	41%	14%	0.10	0.5	0.1	6.16	27.71	1.93
1992	227.19	46%	40%	13%	0.10	0.5	0.1	6.31	27.42	1.84
1993	226.99	47%	40%	13%	0.10	0.5	0.1	6.46	27.10	1.74
1994	226.67	49%	39%	12%	0.10	0.5	0.1	6.60	26.77	1.65
1995	226.38	50%	39%	11%	0.10	0.5	0.1	6.43	26.44	1.56
1996	226.03	51%	39%	11%	0.09	0.5	0.1	6.25	26.11	1.46
1997	225.59	52%	38%	10%	0.09	0.5	0.1	6.05	25.77	1.37
1998	225.13	53%	38%	9%	0.08	0.5	0.1	5.85	25.42	1.28
1999	224.54	54%	37%	9%	0.08	0.5	0.1	5.62	25.07	1.19
2000	223.86	55%	37%	8%	0.07	0.5	0.1	5.38	24.70	1.09
2001	223.38	56%	36%	7%	0.07	0.5	0.1	5.13	24.36	1.00
2002	222.83	59%	34%	7%	0.06	0.5	0.1	5.00	22.85	0.94
2003	222.11	61%	32%	7%	0.06	0.5	0.1	4.83	21.33	0.88
2004	221.56	64%	30%	6%	0.05	0.5	0.1	4.64	19.84	0.83
2005	221.15	67%	28%	6%	0.05	0.5	0.1	4.41	18.36	0.77
2006	220.69	68%	26%	5%	0.00	0.5	0.1	3.50	17.53	0.69
2007	220.45	70%	25%	5%	0.00	0.5	0.1	3.10	16.71	0.61
2008	219.99	72%	24%	4%	0.00	0.5	0.1	2.75	15.89	0.54
2009	219.68	74%	23%	3%	0.00	0.5	0.1	1.32	15.07	0.46
2010	219.31	75%	22%	3%	0.00	0.5	0.1	0.83	14.25	0.38
2011	218.69	77%	20%	2%	0.00	0.5	0.1	0.66	13.42	0.30
2012	218.11	79%	19%	2%	0.00	0.5	0.1	0.58	12.65	0.24

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, emissions from sludge were not calculated separately. It is assumed, however, wherever anaerobic digestion of sludge takes place, the generated methane (reported as

sludge gas in the energy statistics) is recovered and used for energy purposes. Contrary to our previous approach, the recovered methane was reported but was *not* subtracted from the total emissions as no additional methane emission from sludge digestion was taken into account. Nevertheless, we started to collect information on the generated sludge and its handling methods, at least for the last seven years. These data are based on facility reports and are summarized in *Table 8.3.4*.

**Table 8.3.4 Available data on sludge**

	2005	2006	2007	2008	2009	2010	2011	2012
<b>Amount of sludge</b> (dry matter, t/year)	208,330	244,439	210,852	253,161	223,964	284,154	302,989	338,586
<b>Reported N content</b> (t/year)	2,561	3,187	3,061	3,671	3,272	4,769	4,033	3,934
<b>Anaerobic digesting</b> (t/year)	17,900	23,542	22,324	41,408	49,796	109,059	140,402	143,098
<b>Share of anaerobic</b> digesting (%)	9%	10%	11%	16%	22%	38%	46%	42%
<b>Sludge gas</b> (TJ) Source: IEA	193	337	365	337	441	419	742	917
<b>CH<sub>4</sub> Recovery</b> (Gg) calculated	3.83	6.69	7.24	6.69	8.75	8.31	14.72	18.19

It has to be emphasized that emissions from deposited sludge in landfills are taken into account in the SWDS category.

Nitrous oxide emissions were calculated applying Equation 15 from the Revised 1996 IPCC Guidelines with default emission factor (0.01 kg N<sub>2</sub>O-N/kg sewage produced). Our results are summarized in *Table 8.3.5*.

**Table 8.3.5 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	0.97
1990	104.7	1.00
1995	95.0	0.90
2000	96.6	0.91
2001	93.9	0.88
2002	93.5	0.87
2003	103.0	0.96
2004	101.0	0.94
2005	105.4	0.98
2006	104.6	0.97
2007	101.3	0.94
2008	100.6	0.93
2009	99.5	0.92
2010	95.8	0.88
2011	95.8	0.86
2012	95.8	0.86

### 8.3.3 Uncertainties and time-series consistency

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

Uncertainty of the emissions from household wastewater treatment:

Per human populations	-5 % to +5 %
BOD/capita	-30 % to +30 %,
Maximum methane production capacity $B_0$	-30 % to +30 %

Uncertainty of the emissions from industrial wastewater treatment:

Quantity of industrial wastewater:	-25 % to +25 %
Wastewater /unit of production COD/ unit of wastewater:	-50 % to +100 %
Maximum $CH_4$ production capacity $B_0$ :	-30 % to + 30 %

Uncertainty of  $N_2O$  emissions

Emission factor	order of 2
-----------------	------------

Per capita protein consumption	±10%
--------------------------------	------

Used factors	±20%
--------------	------

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

The time series of emissions from domestic wastewater is most probably consistent. As regards industrial wastewater, our current recalculation improved accuracy for the last four year, whereas consistency of the time series suffered.

### 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. Data from the database of facility level wastewater information that are used ultimately by the inventory compiler institute undergoes basic checks, e.g. duplications are removed, outliers are analyzed and corrected whenever necessary.

### 8.3.5 Recalculation

Only minor revision of protein consumption occurred. Also some of the notation keys and additional information have been revised following the recommendations of the ERT.

### 8.3.6 Planned improvements

Improvement in consistency of the time series of the generated total organic product in industrial wastewater.

## 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 8.4.1** Incinerated waste and CO<sub>2</sub> emissions from fossil origin

	BY	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012
<b>Incinerated waste (Gg)</b>	NO	NO	NO	46.56	68.90	65.06	63.66	69.87	84.53	92.36	93.12
<b>Fossil fraction (%)</b>	--	--	--	96%	99%	92%	95%	89%	95%	96%	96%
<b>Fossil CO<sub>2</sub>, Gg</b>	--	--	--	46.98	69.93	64.05	64.12	68.17	84.31	92.88	92.88

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***

General QC procedures have been applied.

***8.4.5 Recalculation***

No recalculation has been taken place.

## 8.5 Composting (CRF sector 6.D)

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

Key source: none

As composting is showing a growing tendency recently, GHG emissions are calculated and reported also for this category for the sake of completeness. Nevertheless, CH<sub>4</sub>, N<sub>2</sub>O emissions cannot be regarded as really substantial.

### 8.5.1 Methodological issues

The Tier 1 method from 2006 Guidelines was used with default emission factors.

### 8.5.2 Activity data

Amount of composted waste was received from the Hungarian Central Statistical Office. In 2012, 182.873 Gg waste was composted which represented 4.6% of all generated MSW.

**Table 8.5.1** Activity data, emission factors and emissions from composting

YEAR	Amount	CH <sub>4</sub> EF	N <sub>2</sub> O EF	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> eq
	Gg	g/kg	g/kg	Gg	Gg	Gg
1996	18	4	0.3	0.07	0.01	3.19
1997	19	4	0.3	0.08	0.01	3.36
1998	18	4	0.3	0.07	0.01	3.19
1999	18	4	0.3	0.07	0.01	3.19
2000	17	4	0.3	0.07	0.01	3.01
2001	17	4	0.3	0.07	0.01	3.01
2002	47	4	0.3	0.19	0.01	8.32
2003	47	4	0.3	0.19	0.01	8.32
2004	39	4	0.3	0.16	0.01	6.90
2005	41	4	0.3	0.16	0.01	7.26
2006	58	4	0.3	0.23	0.02	10.27
2007	64	4	0.3	0.26	0.02	11.33
2008	85	4	0.3	0.34	0.03	15.05
2009	90	4	0.3	0.36	0.03	15.93
2010	148	4	0.3	0.59	0.04	26.20
2011	183	4	0.3	0.73	0.05	32.39
2012	183	4	0.3	0.73	0.05	32.37

### 8.5.3 Uncertainties and time-series consistency

No category specific information is available.

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

The used data from Eurostat was compared with data from the Hungarian Central Statistical Office.

### 8.5.5 Source-specific planned improvements

None.

## 9. OTHER (CRF sector 7.)

This sector is not in use.

## 10. RECALCULATIONS AND PLANNED IMPROVEMENTS

### 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

#### 1.A Fuel Combustion

For this submission, quite substantial changes have been made in the energy sector. The main rationale of the recalculation was that the publication of the Energy Statistical Yearbook has been ceased. Previously most of our activity data were taken from this series of yearbooks. After consultations with the energy statistics provider, we decided to base our calculations on the joint IEA/Eurostat questionnaires. The choice of using the data submitted to the IEA has the following advantages. The structure of the IEA tables is more similar to the CRF tables, and the times series can be regarded as more consistent whereas the structure and the user categories in the Energy Statistical Yearbooks had changed several times since 1985. Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics also requires that every reasonable effort shall be undertaken to ensure coherence between energy data and the data reported for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol. Moreover, the fuel classification in the IEA database is the same as required by the IPCC guidelines whereas for example the Hungarian coal classification system uses a quite different philosophy. Also the ERT recommended to revise classification for coal and to include more detailed explanation of reasons for differences in the CRF tables and the IEA data in the next submission.

Revisions were made for the whole times series, i.e. back to 1985. The overall effects of the changes are summarized in *Table 10.2.1* below. Some of the amendments resulted from simple reallocations between source categories. In case of liquid fuels, however, more fuel categories were taken into account, and the share of non-energy use has also been revised. Without doubt, solid fuel caused the most problems mainly because the fuel classification had to be changed. The country specific carbon emission factors were previously determined for the Hungarian categories, namely hard coal, brown coal, and lignite. Now, new factors had to be applied for other bituminous coal, sub-bituminous coal and lignite. Most of the coal produced in Hungary can be classified as lignite in this new system irrespectively whether it stemmed from surface or underground mines, although they have different characteristics. To take into account the changing share of the higher quality lignite from underground production, a time dependent carbon emission factor (changing between 27.4 and 29.9 t C/TJ) was introduced and applied for the pre-ETS years.

**Table 10.2.1** Overall effect of recalculation in 1.A Fuel Consumption

	FUEL CONSUMPTION (TJ)			TOTAL GHG EMISSIONS (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
<b>1985</b>	1,026,465	1,032,604	0.6%	77,424	79,390	2.5%
<b>1985-87</b>	1,019,330	1,025,272	0.6%	76,431	78,425	2.6%
<b>1986</b>	1,011,446	1,016,749	0.5%	75,625	77,758	2.8%
<b>1987</b>	1,020,079	1,026,464	0.6%	76,243	78,127	2.5%
<b>1988</b>	970,165	978,380	0.8%	72,208	74,421	3.1%
<b>1989</b>	956,186	961,111	0.5%	70,476	71,786	1.9%
<b>1990</b>	902,234	918,367	1.8%	65,760	67,397	2.5%
<b>1991</b>	895,733	904,493	1.0%	65,021	65,604	0.9%
<b>1992</b>	820,610	818,210	-0.3%	59,118	58,917	-0.3%
<b>1993</b>	832,503	833,957	0.2%	59,322	59,798	0.8%
<b>1994</b>	812,967	809,701	-0.4%	57,345	57,457	0.2%
<b>1995</b>	813,799	818,668	0.6%	56,602	57,325	1.3%
<b>1996</b>	843,102	851,068	0.9%	58,281	59,091	1.4%
<b>1997</b>	823,092	829,325	0.8%	57,149	57,739	1.0%
<b>1998</b>	814,032	827,142	1.6%	56,098	57,206	2.0%
<b>1999</b>	817,818	835,216	2.1%	56,451	57,896	2.6%
<b>2000</b>	784,753	787,321	0.3%	54,011	54,235	0.4%
<b>2001</b>	818,743	825,994	0.9%	55,860	56,130	0.5%
<b>2002</b>	803,222	815,864	1.6%	54,335	55,169	1.5%
<b>2003</b>	858,268	864,066	0.7%	57,714	58,015	0.5%
<b>2004</b>	837,338	838,491	0.1%	55,684	56,085	0.7%
<b>2005</b>	859,208	856,524	-0.3%	54,758	55,625	1.6%
<b>2006</b>	839,892	845,709	0.7%	54,006	55,254	2.3%
<b>2007</b>	816,720	822,889	0.8%	52,209	53,640	2.7%
<b>2008</b>	816,108	819,601	0.4%	51,147	52,589	2.8%
<b>2009</b>	745,521	755,927	1.4%	46,440	47,927	3.2%
<b>2010</b>	765,246	773,390	1.1%	46,676	48,529	4.0%
<b>2011</b>	734,399	740,200	0.8%	45,040	46,824	4.0%
<b>AVG</b>			<b>0.7%</b>			<b>1.9%</b>

It can be seen from the table above that total fuel consumption changed by 0.7% on average. The recalculation had a bit larger effect on the total GHG emissions from fuel consumption, i.e. 1.9% probably due to reallocation of emissions from blast furnace gas from the industrial processes sector.

However, looking at the changes on fuel level (see Tables 10.2.2 and 10.2.3), we might discover larger changes especially in case of biomass and other fuels. Although it has no consequence on CO<sub>2</sub> emissions, biomass consumption increased by 71.2 per cent on average. Further changes in relation with solid fuels and waste incineration are explained under 1.A.1.a.

**Table 10.2.2** Changes in fuel consumption and CO<sub>2</sub> emissions for liquid, solid, and gaseous fuels due to recent recalculations (see next page)

TJ	LIQUID			SOLID			GASEOUS		
	OLD	NEW	DIFF	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	347,120	350,588	1.0%	319,994	327,178	2.2%	342,943	330,025	-3.8%
1985-87	333,441	335,562	0.6%	313,856	320,823	2.2%	356,939	346,133	-3.0%
1986	321,811	323,144	0.4%	310,197	317,485	2.3%	365,209	354,609	-2.9%
1987	331,394	332,953	0.5%	311,377	317,806	2.1%	362,664	353,767	-2.5%
1988	297,675	298,326	0.2%	298,928	308,638	3.2%	360,016	352,507	-2.1%
1989	295,274	295,387	0.0%	279,933	282,652	1.0%	367,712	362,766	-1.3%
1990	295,840	297,549	0.6%	240,170	243,655	1.5%	355,535	349,675	-1.6%
1991	281,148	280,455	-0.2%	239,197	237,768	-0.6%	359,815	356,410	-0.9%
1992	291,547	282,184	-3.2%	194,068	192,563	-0.8%	318,799	313,226	-1.7%
1993	292,791	278,596	-4.8%	181,437	187,129	3.1%	341,727	337,106	-1.4%
1994	287,289	273,134	-4.9%	165,103	166,124	0.6%	343,705	339,053	-1.4%
1995	260,151	253,911	-2.4%	160,728	163,456	1.7%	374,241	368,036	-1.7%
1996	242,424	238,443	-1.6%	165,674	168,644	1.8%	417,720	411,212	-1.6%
1997	247,173	239,723	-3.0%	162,333	167,311	3.1%	396,013	390,283	-1.4%
1998	245,986	247,037	0.4%	148,774	154,388	3.8%	402,681	393,641	-2.2%
1999	242,973	245,401	1.0%	150,934	157,425	4.3%	407,309	400,096	-1.8%
2000	225,094	222,751	-1.0%	145,918	145,441	-0.3%	395,857	387,391	-2.1%
2001	225,600	221,101	-2.0%	137,076	139,110	1.5%	439,529	432,459	-1.6%
2002	210,289	209,537	-0.4%	131,434	135,077	2.8%	444,717	437,896	-1.5%
2003	206,626	206,948	0.2%	142,192	141,555	-0.4%	488,281	481,187	-1.5%
2004	206,305	201,329	-2.4%	130,955	130,168	-0.6%	471,244	470,066	-0.2%
2005	205,396	206,974	0.8%	109,490	112,542	2.8%	494,855	488,559	-1.3%
2006	219,277	217,568	-0.8%	106,654	111,536	4.6%	467,594	465,101	-0.5%
2007	223,202	220,305	-1.3%	107,210	112,089	4.6%	433,859	433,025	-0.2%
2008	216,687	216,708	0.0%	105,348	109,550	4.0%	428,405	427,556	-0.2%
2009	217,886	216,112	-0.8%	87,258	93,453	7.1%	371,896	371,003	-0.2%
2010	199,942	200,508	0.3%	88,804	97,060	9.3%	397,469	396,319	-0.3%
2011	191,910	190,234	-0.9%	90,894	98,488	8.4%	376,056	375,949	0.0%
AVG			-0.9%			2.7%			-1.5%
CO2	LIQUID			SOLID			GASEOUS		
	OLD	NEW	DIFF	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	25,371.29	25,833.94	1.8%	31,522.51	33,783.96	7.2%	19,142.93	18,421.80	-3.8%
1985-87	24,364.01	24,689.29	1.3%	30,810.81	33,110.57	7.5%	19,924.15	19,320.99	-3.0%
1986	23,518.49	23,757.49	1.0%	30,424.12	32,930.80	8.2%	20,385.76	19,794.09	-2.9%
1987	24,202.25	24,476.46	1.1%	30,485.81	32,616.94	7.0%	20,243.77	19,747.08	-2.5%
1988	21,708.21	21,871.83	0.8%	29,105.68	31,585.92	8.5%	20,095.94	19,676.79	-2.1%
1989	21,513.61	21,478.65	-0.2%	27,259.40	28,895.29	6.0%	20,525.49	20,249.44	-1.3%
1990	21,491.49	21,749.58	1.2%	23,375.76	25,016.89	7.0%	19,845.83	19,518.71	-1.6%
1991	20,513.66	20,579.62	0.3%	23,320.94	24,023.28	3.0%	20,084.69	19,894.63	-0.9%
1992	21,336.54	20,791.85	-2.6%	19,132.84	19,805.45	3.5%	17,795.20	17,484.12	-1.7%
1993	21,427.10	20,559.54	-4.0%	17,970.36	19,526.54	8.7%	19,075.01	18,817.09	-1.4%
1994	21,033.50	20,171.36	-4.1%	16,339.24	17,567.99	7.5%	19,185.45	18,925.80	-1.4%
1995	19,024.99	18,717.99	-1.6%	15,912.95	17,305.05	8.7%	20,889.89	20,543.56	-1.7%
1996	17,699.34	17,552.05	-0.8%	16,483.61	17,796.11	8.0%	23,316.93	22,953.62	-1.6%
1997	18,091.66	17,727.21	-2.0%	16,180.52	17,401.76	7.5%	22,105.27	21,785.41	-1.4%
1998	18,062.58	18,268.17	1.1%	14,852.99	16,190.30	9.0%	22,477.48	21,972.86	-2.2%
1999	17,838.32	18,163.02	1.8%	15,141.43	16,566.70	9.4%	22,735.78	22,333.18	-1.8%
2000	16,574.25	16,401.20	-1.0%	14,615.59	15,430.94	5.6%	22,096.63	21,623.97	-2.1%
2001	16,601.04	16,259.53	-2.1%	13,958.12	14,883.18	6.6%	24,534.87	24,139.65	-1.6%
2002	15,316.12	15,292.51	-0.2%	13,434.19	14,574.00	8.5%	24,823.90	24,443.15	-1.5%
2003	15,084.71	15,139.96	0.4%	14,545.57	15,142.89	4.1%	27,255.60	26,859.61	-1.5%
2004	15,092.94	14,750.53	-2.3%	13,444.13	14,250.93	6.0%	26,304.58	26,238.86	-0.2%
2005	15,057.07	15,202.66	1.0%	11,204.42	12,381.81	10.5%	27,622.54	27,271.10	-1.3%
2006	16,115.26	15,986.67	-0.8%	10,871.20	12,403.90	14.1%	26,100.88	25,961.68	-0.5%
2007	16,352.96	16,183.69	-1.0%	10,639.35	12,280.84	15.4%	24,217.78	24,171.26	-0.2%
2008	15,923.80	15,912.11	-0.1%	10,380.38	11,877.36	14.4%	23,913.36	23,867.78	-0.2%
2009	15,978.15	15,858.73	-0.7%	8,754.84	10,380.00	18.6%	20,759.43	20,710.57	-0.2%
2010	14,636.31	14,677.48	0.3%	8,841.74	10,773.04	21.8%	22,186.53	22,068.70	-0.5%
2011	14,011.14	13,891.63	-0.9%	9,089.27	10,978.22	20.8%	20,991.26	20,959.84	-0.1%
AVG			-0.4%			9.4%			-1.5%

**Table 10.2.3** *Changes in fuel consumption and CO<sub>2</sub> emissions for biomass and other fuels due to recent recalculations*

	BIOMASS (TJ)			OTHER (TJ)			OTHER CO <sub>2</sub> (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	14,338	23,048	60.7%	2,071	1,766	-14.7%	101.09	45.62	-54.9%
1985-87	13,095	21,183	61.8%	1,999	1,571	-21.4%	97.62	44.08	-54.9%
1986	12,371	20,033	61.9%	1,859	1,478	-20.5%	90.76	40.98	-54.9%
1987	12,575	20,469	62.8%	2,069	1,470	-28.9%	101.01	45.63	-54.8%
1988	11,875	17,756	49.5%	1,671	1,153	-31.0%	81.59	36.87	-54.8%
1989	12,663	19,862	56.9%	605	444	-26.6%	29.55	13.36	-54.8%
1990	9,401	26,499	181.9%	1,288	988	-23.3%	62.87	27.82	-55.7%
1991	13,422	28,242	110.4%	2,151	1,618	-24.8%	105.04	44.65	-57.5%
1992	13,307	28,090	111.1%	2,889	2,148	-25.7%	141.06	58.08	-58.8%
1993	13,863	29,008	109.2%	2,684	2,118	-21.1%	131.06	66.89	-49.0%
1994	14,000	28,920	106.6%	2,870	2,470	-14.0%	140.15	71.78	-48.8%
1995	15,875	31,095	95.9%	2,804	2,170	-22.6%	136.91	50.48	-63.1%
1996	14,475	30,395	110.0%	2,808	2,374	-15.5%	137.12	59.53	-56.6%
1997	14,688	29,608	101.6%	2,885	2,400	-16.8%	140.85	95.21	-32.4%
1998	13,562	29,582	118.1%	3,029	2,494	-17.7%	147.86	111.25	-24.8%
1999	13,608	29,828	119.2%	2,994	2,466	-17.6%	146.16	135.91	-7.0%
2000	14,925	29,301	96.3%	2,959	2,436	-17.7%	144.46	108.41	-25.0%
2001	13,539	30,725	126.9%	3,000	2,598	-13.4%	146.45	139.09	-5.0%
2002	14,592	31,358	114.9%	2,190	1,996	-8.8%	106.90	124.17	16.2%
2003	19,534	32,868	68.3%	1,634	1,508	-7.7%	99.42	88.00	-11.5%
2004	26,151	34,636	32.4%	2,684	2,292	-14.6%	117.60	86.57	-26.4%
2005	43,802	43,933	0.3%	5,666	4,517	-20.3%	298.04	210.94	-29.2%
2006	39,720	45,103	13.6%	6,647	6,402	-3.7%	327.87	314.26	-4.2%
2007	44,992	50,095	11.3%	7,456	7,374	-1.1%	438.70	427.41	-2.6%
2008	58,500	58,886	0.7%	7,168	6,902	-3.7%	394.05	383.51	-2.7%
2009	61,678	68,777	11.5%	6,803	6,582	-3.2%	410.33	410.95	0.2%
2010	72,222	72,694	0.7%	6,809	6,809	0.0%	420.76	421.43	0.2%
2011	69,321	69,312	0.0%	6,217	6,217	0.0%	343.78	393.74	14.5%
AVG			71.2%			-15.6%			-30.6%

### 1.A.1.a Public Electricity and Heat Production

In addition to the general recalculations/reallocations in the energy sector in order to be consistent with the energy statistics submitted to the IEA described above, the following amendments took place in this source category:

- **Reallocation emissions from blast furnace gas used for energy purposes** from 2.C.1.4 Iron and Steel/Coke. Blast furnace gas consumption as activity data were taken from the IEA questionnaires. As for emission factors, plant specific data were taken from the ETS database for 2006-2012, and their average value, i.e. 255.7 t CO<sub>2</sub>/TJ, was used for the preceding years. Table 10.2.4 summarizes the effects of the recalculation.
- **Re-derived emission factors for lignite** for the period 1990-2004. Instead of constant EFs used previously, changing ratio of lignite from underground and surface mines are now taken into account;
- **Recalculation of emissions (and activity data) from waste incineration.** Previously, the fuel content of the waste was estimated by using the amount of incinerated waste with a constant calorific value of 8.5 GJ/t waste. In this submission, we moved toward IEA data, and fuel consumption data were directly taken from the IEA questionnaire "Renewables and Wastes". In the Hungarian submission to the IEA, 50 per cent of the incinerated municipal waste is considered as renewable and the other half as non-renewable consistently for the entire time series. Please note that in the CRF tables the total amount is reported. Nevertheless, not the fuel content

of the waste (TJ) but the waste amount (kt) was used for the estimation of CO<sub>2</sub> emissions both in previous and current submission. In the previous submission, for the years before 2004, 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. Now, in this submission, our calculations are based on yearly changing waste composition data for the entire time series. 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. Waste composition changed quite significantly in the last decades, which is reflected in the changing (i.e. increasing) implied emission factor. Most importantly, the share of plastics that was less than 5 per cent in 1990 grew to 21.2 per cent in 2012 which means a significant increase in incinerated fossil carbon. Table 10.2.5 below summarizes the resulting changes.

- **Use of country-specific emission factor for natural gas** for the years 2010-12 (55.3, 55.6, and 55.6 t CO<sub>2</sub>/TJ) based on ETS data of larger power plants. The resulting change for 2011 is -20.4 Gg, or -0.3 per cent, so it cannot be regarded as significant.

**Table 10.2.4** Effects of recalculation in 1.A.1.a Public Electricity and Heat Production in relation with solid fuels

	SOLID FUEL USE (TJ)			CO <sub>2</sub> EMISSION (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	139,945	137,101	-2.0%	14,223.6	13,519.8	-4.9%
1985-87	143,702	141,183	-1.8%	14,582.4	13,912.6	-4.6%
1986	145,085	143,063	-1.4%	14,714.9	14,089.9	-4.2%
1987	146,075	143,385	-1.8%	14,808.9	14,128.2	-4.6%
1988	135,718	134,116	-1.2%	13,619.4	13,152.4	-3.4%
1989	129,878	133,307	2.6%	13,046.5	13,114.7	0.5%
1990	126,496	124,395	-1.7%	12,725.3	12,266.1	-3.6%
1991	118,603	116,294	-1.9%	11,971.6	11,471.6	-4.2%
1992	122,329	120,629	-1.4%	12,451.1	12,075.0	-3.0%
1993	116,585	113,871	-2.3%	11,930.6	11,436.0	-4.1%
1994	110,583	108,391	-2.0%	11,351.8	10,902.9	-4.0%
1995	113,962	114,165	0.2%	11,703.7	11,513.2	-1.6%
1996	117,792	118,016	0.2%	12,137.6	11,915.4	-1.8%
1997	121,176	120,489	-0.6%	12,498.8	12,190.8	-2.5%
1998	120,525	127,964	6.2%	12,402.5	13,501.4	8.9%
1999	122,393	127,704	4.3%	12,615.8	13,528.0	7.2%
2000	118,607	119,676	0.9%	12,260.0	12,781.0	4.2%
2001	111,513	115,532	3.6%	11,610.8	12,355.1	6.4%
2002	107,577	111,704	3.8%	11,190.8	11,982.7	7.1%
2003	116,889	116,954	0.1%	12,208.8	12,558.6	2.9%
2004	107,969	107,996	0.0%	11,340.9	11,840.8	4.4%
2005	84,399	89,031	5.5%	8,942.7	9,816.1	9.8%
2006	81,274	85,299	5.0%	8,758.0	9,720.0	11.0%
2007	85,388	89,683	5.0%	8,890.6	10,038.9	12.9%
2008	82,105	86,283	5.1%	8,495.9	9,561.9	12.5%
2009	71,949	75,837	5.4%	7,548.6	8,510.2	12.7%
2010	71,830	77,068	7.3%	7,526.0	8,735.5	16.1%
2011	72,700	77,392	6.5%	7,651.4	8,838.4	15.5%
AVG			1.6%			3.1%

**Table 10.2.5** Effects of recalculation in 1.A.1.a Public Electricity and Heat Production in relation with waste incineration

	WASTE FUEL USE (TJ)			CO2 EMISSION (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
1985	2,071	1,766	-14.7%	101.09	45.62	-54.9%
1985-87	1,999	1,571	-21.4%	97.62	44.08	-54.9%
1986	1,859	1,478	-20.5%	90.76	40.98	-54.9%
1987	2,069	1,470	-28.9%	101.01	45.63	-54.8%
1988	1,671	1,153	-31.0%	81.59	36.87	-54.8%
1989	605	444	-26.6%	29.55	13.36	-54.8%
1990	1,288	988	-23.3%	62.87	27.82	-55.7%
1991	2,151	1,618	-24.8%	105.04	44.65	-57.5%
1992	2,889	2,148	-25.7%	141.06	58.08	-58.8%
1993	2,684	2,118	-21.1%	131.06	66.89	-49.0%
1994	2,870	2,470	-14.0%	140.15	71.78	-48.8%
1995	2,804	2,170	-22.6%	136.91	50.48	-63.1%
1996	2,808	2,374	-15.5%	137.12	59.53	-56.6%
1997	2,885	2,400	-16.8%	140.85	95.21	-32.4%
1998	3,029	2,494	-17.7%	147.86	111.25	-24.8%
1999	2,994	2,466	-17.6%	146.16	135.91	-7.0%
2000	2,959	2,436	-17.7%	144.46	108.41	-25.0%
2001	3,000	2,598	-13.4%	146.45	139.09	-5.0%
2002	2,190	1,996	-8.8%	106.90	124.17	16.2%
2003	1,634	1,508	-7.7%	99.42	88.00	-11.5%
2004	1,766	1,374	-22.2%	106.44	75.40	-29.2%
2005	4,067	2,918	-28.3%	240.68	153.58	-36.2%
2006	4,572	4,327	-5.4%	258.77	245.17	-5.3%
2007	4,664	4,582	-1.8%	336.13	324.84	-3.4%
2008	4,192	3,926	-6.3%	285.10	274.56	-3.7%
2009	4,126	3,906	-5.3%	269.78	270.39	0.2%
2010	4,486	4,486	0.0%	279.37	280.04	0.2%
2011	4,188	4,188	0.0%	278.52	279.17	0.2%
AVG			-16.4%			-31.6%

**1.A.1.b Petroleum Refining**

Plant specific CO<sub>2</sub> emission factors based on ETS data has been introduced for natural gas for the years 2008-2012 as follows: 56.1; 56.0; 56.6; 55.3; 55.6 t CO<sub>2</sub>/TJ. The resulting change for 2011 is -5.0 Gg, or -0.9 per cent.

**1.A.1.c Manufacture of Solid Fuels and Other Energy Industries**

The same as above, plant specific CO<sub>2</sub> emission factors based on ETS data has been introduced for natural gas but only for the years 2010-2012 (56.1; 56.2; 55.8 t CO<sub>2</sub>/TJ) which meant an increase of 0.7 per cent in 2011.

### 1.A.2. Manufacturing Industries and Construction

Emissions from blast furnace gas from Industrial Processes have been reallocated to 1.A.2.a Iron and Steel. This represents about 700 Gg of additional CO<sub>2</sub> emissions in the first commitment period (+2,219 Gg in 1990 and +684 Gg in 2011);

New country specific emission factors have been introduced for a mixed fuel containing petroleum coke and different coal types in 1.A.2.f – Non-metallic Minerals.

#### 1.A.3.a Civil Aviation

Although there are no scheduled commercial domestic flights in Hungary, Eurocontrol data for 2012 suggested that 0.3 per cent of total jet kerosene is used for domestic flights. Using the same share back to 1985, some kerosene use is now allocated to domestic aviation. The resulting CO<sub>2</sub> emission is 1.5 Gg on average.

**Table 10.2.6** 0.3 per cent of total jet kerosene use is allocated to domestic aviation

	OLD TJ	NEW TJ	NEW CO <sub>2</sub>
1985	NO	15.6	1.1
1985-87	NO	15.6	1.1
1986	NO	15.8	1.1
1987	NO	15.4	1.1
1988	NO	15.6	1.1
1989	NO	16.3	1.2
1990	NO	17.3	1.2
1991	NO	13.6	1.0
1992	NO	14.4	1.0
1993	NO	13.2	0.9
1994	NO	19.9	1.4
1995	NO	19.1	1.4
1996	NO	20.3	1.4
1997	NO	19.3	1.4
1998	NO	20.2	1.4
1999	NO	21.7	1.5
2000	NO	24.2	1.7
2001	NO	22.9	1.6
2002	NO	21.6	1.5
2003	NO	21.1	1.5
2004	NO	24.3	1.7
2005	NO	28.2	2.0
2006	NO	28.5	2.0
2007	NO	26.1	1.8
2008	NO	29.0	2.1
2009	NO	24.8	1.8
2010	NO	24.7	1.7
2011	NO	24.8	1.8
AVG			1.4

In addition, jet kerosene use for international aviation has been harmonized with the IEA data retrospectively. The changes are summarized in Table 10.2.7.

**Table 10.2.7** Jet kerosene consumption has been harmonized with the IEA database

	KEROSENE USE (TJ)			CO2 EMISSION (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
<b>1985</b>	6085	6090	0.1%	430.7267	431.0807	0.1%
<b>1985-87</b>	6094.333	6076	-0.3%	431.3874	430.0897	-0.3%
<b>1986</b>	6168	6132	-0.6%	436.6019	434.0536	-0.6%
<b>1987</b>	6030	6006	-0.4%	426.8336	425.1347	-0.4%
<b>1988</b>	6104	6090	-0.2%	432.0716	431.0807	-0.2%
<b>1989</b>	6331	6342	0.2%	448.1398	448.9185	0.2%
<b>1990</b>	6711	6720	0.1%	475.0381	475.6752	0.1%
<b>1991</b>	5310	5292	-0.3%	375.8684	374.5942	-0.3%
<b>1992</b>	5451	5586	2.5%	385.849	395.405	2.5%
<b>1993</b>	5102	5124	0.4%	361.1451	362.7023	0.4%
<b>1994</b>	7519	7728	2.8%	532.2324	547.0265	2.8%
<b>1995</b>	7401	7434	0.4%	523.8798	526.2157	0.4%
<b>1996</b>	7905	7896	-0.1%	559.5554	558.9184	-0.1%
<b>1997</b>	7505	7518	0.2%	531.2414	532.1616	0.2%
<b>1998</b>	7849	7854	0.1%	555.5915	555.9454	0.1%
<b>1999</b>	8424	8442	0.2%	596.2928	597.567	0.2%
<b>2000</b>	8957	9408	5.0%	634.0212	665.9453	5.0%
<b>2001</b>	7602	8904	17.1%	538.1076	630.2696	17.1%
<b>2002</b>	8150	8400	3.1%	576.8978	594.594	3.1%
<b>2003</b>	8358	8232	-1.5%	591.621	582.7021	-1.5%
<b>2004</b>	8610	9450	9.8%	609.4589	668.9183	9.8%
<b>2005</b>	9368	10962	17.0%	663.1139	775.9452	17.0%
<b>2006</b>	9210	11088	20.4%	651.9299	784.8641	20.4%
<b>2007</b>	10145	10164	0.2%	718.1138	719.4587	0.2%
<b>2008</b>	11303.46	11298	0.0%	800.1154	799.7289	0.0%
<b>2009</b>	9672	9660	-0.1%	684.6325	683.7831	-0.1%
<b>2010</b>	9618	9618	0.0%	680.8101	680.8101	0.0%
<b>2011</b>	9660	9660	0.0%	683.7831	683.7831	0.0%
<b>AVG</b>			<b>2.7%</b>			<b>2.7%</b>

### 1.B.1.b. Fugitive emissions from solid fuel transformation

In 2014 submission notation key of activity data has been changed from NO to IE as required by 2013 review in order to reach consistency with notation key of emissions. IE notation key is applied because emissions from solid fuel transformation are included in 1.A.1.c. Manufacture of solid fuels.

### 1.B.2. Fugitive emissions from oil and gas operations

Comment of IE notation key of subsector 1.B.2.a.i Oil exploration has been corrected to "IE to 1.B.2.b.i and to 1.B.2.C.2.1" as required by 2013 review.

In 2014 submission, CO<sub>2</sub> emission in 1B2b3 is included based on GPG Table 2.16 T1 emission factor. With the inclusion of some other missing estimation, the application of T1 factors from the GPG Table 2.16 are now complete and presented in NIR chapter 3.3.2.

The recalculation resulted in less than 1 Gg increase of emission of CO<sub>2</sub> in sector 1.B.2.

**Table 10.2.8** Change in CO<sub>2</sub> emissions in 1.B.2 sector

	1985	BY	1990	1995	2000	2005	2008	2010	2011	2012
<b>2013 submission 1.B.2. only CO<sub>2</sub> (Gg CO<sub>2</sub>)</b>	365.7	360.2	288.9	316.5	226.8	136.3	211.1	219.5	215.1	174.7
<b>2014 submission 1.B.2. only CO<sub>2</sub> (Gg CO<sub>2</sub>)</b>	367.2	361.6	289.8	317.1	227.4	136.9	211.6	220.1	215.6	175.3
<b>difference NEW - OLD (Gg CO<sub>2</sub>)</b>	1.51	1.48	0.91	0.59	0.59	0.56	0.58	0.55	0.52	0.54
<b>difference %</b>	0.4%	0.4%	0.3%	0.2%	0.3%	0.4%	0.3%	0.3%	0.2%	0.3%

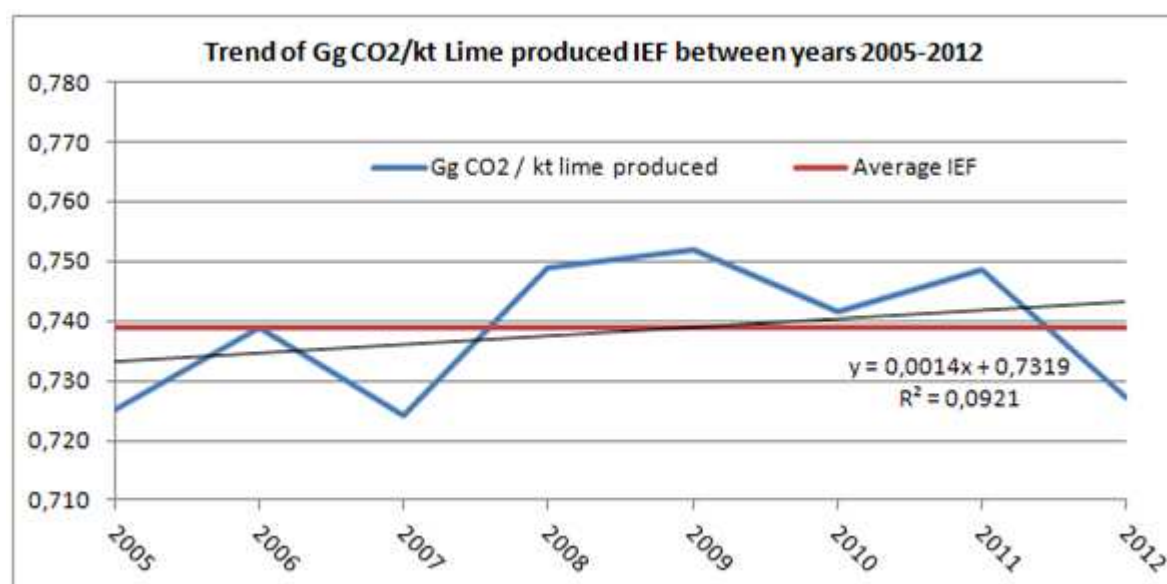
## 10.3 Industry sector

### 2.A.2. Lime

In category 2.A.2. Lime production category time series have been recalculated by using EU ETS emission data of companies in years 2005-2012 and using the average of the IEFs of this years for the years before 2005. The IEFs of all years and comparison of time series are presented in Table 10.3.2..

The IEF of years between 2005-2012 do not show a clear trend as it is presented in Figure 10.3.1. therefore the average seems to be applicable for extrapolation for the years before 2005 in order to reach consistent time series.

The average of years 2005-2012 results in 0.7388 t CO<sub>2</sub>/t lime produced which is 5.9% lower than the stoichiometric IEF of 0.785 and it is well fitting in the IEF range 0.56-0.8 applied by other countries as presented in SAI 2013.

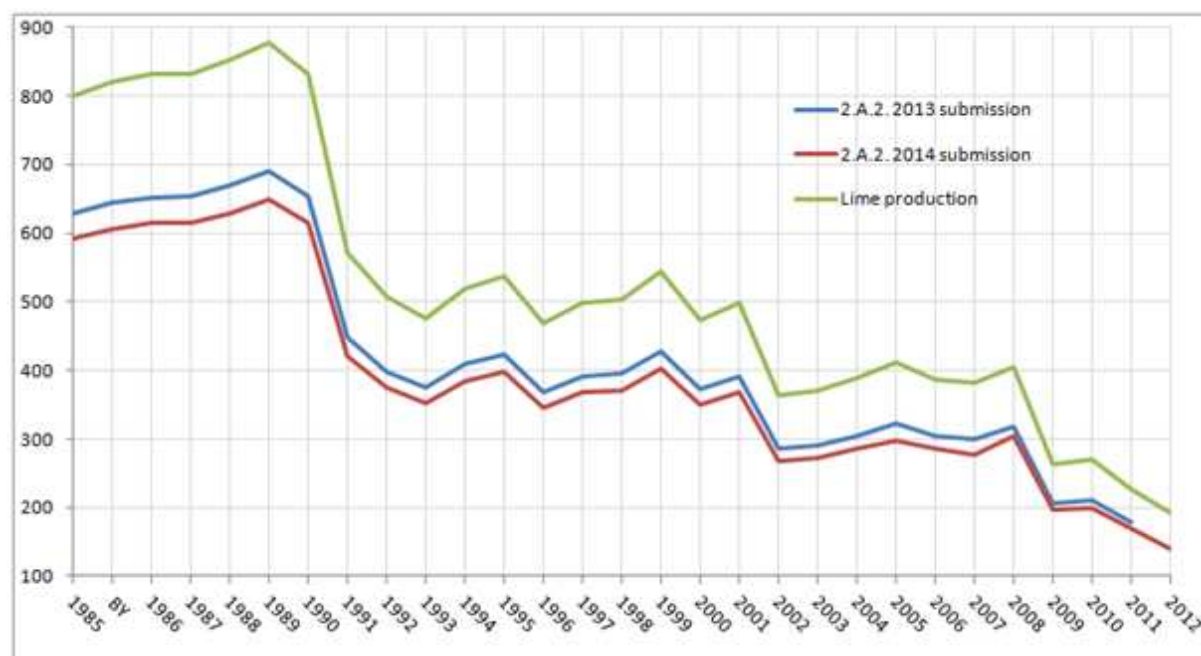


**Figure 10.3.1** Trend of Gg CO<sub>2</sub>/kt Lime produced IEF between years 2005-2012

Exact carbonate contents of the raw material and the remaining carbonate content of the products determined by accredited laboratories are used for the calculations in EU ETS Annual Emission Reports (AERs). So, using EU ETS data, the emissions from the minor proportion of dolomitic lime (containing MgCO<sub>3</sub>), impurities and the eventual presence of hydraulic lime (which has the same stoichiometric ratio as lime but has a lower CaO content (see page 3.22 of the GPG)) are also taken into account as it is required by GPG chapter 3.1.2.1.

**Table 10.3.1** MgCO<sub>3</sub> and remaining carbonate contents in EU ETS 2012 data

	2012.
MgCO <sub>3</sub> content of raw material in EU ETS AER-s	0.44%-2.24%
Conversion factors due to remaining carbonate content of the product in EU ETS AER-s	0.901-0.979

**Figure 10.3.2** Time series in sector 2.A.2.Lime**Table 10.3.2** Change in CO<sub>2</sub> emissions from sector 2.A.2. Lime

		1985	BY	1986	1987	1988	1989	1990
Lime production	kt	801.0	821.3	831.0	832.0	851.4	878.0	831.0
OLD 2013 submission 2.A.2. CO <sub>2</sub> emission	CO <sub>2</sub> Gg	629.4	645.0	652.0	653.7	669.0	689.2	652.9
<b>NEW 2014 submission 2.A.2. CO<sub>2</sub> Emission</b>	<b>CO<sub>2</sub> Gg</b>	<b>591.8</b>	<b>606.8</b>	<b>613.9</b>	<b>614.7</b>	<b>629.0</b>	<b>648.7</b>	<b>613.9</b>
<i>new-old</i>	<i>Gg CO<sub>2</sub></i>	-37.6	-38.2	-38.1	-39.0	-40.0	-40.6	-39.0
<i>Difference</i>	%	-6.0%	-5.9%	-5.8%	-6.0%	-6.0%	-5.9%	-6.0%
IEF	Gg CO <sub>2</sub> / kt lime	0.739	0.739	0.739	0.739	0.739	0.739	0.739
		1991	1992	1993	1994	1995	1996	1997
<b>Lime production</b>	<b>kt</b>	<b>571.0</b>	<b>507.0</b>	<b>476.0</b>	<b>520.0</b>	<b>538.0</b>	<b>467.9</b>	<b>498.3</b>
OLD 2013 submission 2.A.2. CO <sub>2</sub> emission	CO <sub>2</sub> Gg	448.6	398.4	374.0	408.6	422.7	367.6	391.2
<b>NEW 2014 submission 2.A.2. CO<sub>2</sub> Emission</b>	<b>CO<sub>2</sub> Gg</b>	<b>421.8</b>	<b>374.6</b>	<b>351.7</b>	<b>384.2</b>	<b>397.5</b>	<b>345.7</b>	<b>368.2</b>
<i>new-old</i>	<i>Gg CO<sub>2</sub></i>	-26.8	-23.8	-22.3	-24.4	-25.2	-22.0	-23.0
<i>Difference</i>	%	-6.0%	-6.0%	-6.0%	-6.0%	-6.0%	-6.0%	-5.9%
IEF	Gg CO <sub>2</sub> / kt lime	0.739	0.739	0.739	0.739	0.739	0.739	0.739

		1998	1999	2000	2001	2002	2003	2004
<b>Lime production</b>	<b>kt</b>	<b>502.4</b>	<b>543.5</b>	<b>473.8</b>	<b>498.5</b>	<b>363.5</b>	<b>369.9</b>	<b>388.5</b>
OLD 2013 submission 2.A.2. CO2 emission	CO2 Gg	394.8	426.6	371.9	391.3	285.4	290.4	305.0
<b>NEW 2014 submission 2.A.2. CO2 Emission</b>	<b>CO2 Gg</b>	<b>371.2</b>	<b>401.5</b>	<b>350.0</b>	<b>368.3</b>	<b>268.5</b>	<b>273.3</b>	<b>287.0</b>
<i>new-old</i>	<i>Gg CO2</i>	<i>-23.6</i>	<i>-25.1</i>	<i>-21.9</i>	<i>-23.0</i>	<i>-16.8</i>	<i>-17.1</i>	<i>-18.0</i>
<i>Difference</i>	<i>%</i>	<i>-6.0%</i>	<i>-5.9%</i>	<i>-5.9%</i>	<i>-5.9%</i>	<i>-5.9%</i>	<i>-5.9%</i>	<i>-5.9%</i>
IEF	Gg CO2 / kt lime	0.739	0.739	0.739	0.739	0.739	0.739	0.739
		2005	2006	2007	2008	2009	2010	2011
<b>Lime production</b>	<b>kt</b>	<b>411.6</b>	<b>387.1</b>	<b>383.1</b>	<b>405.7</b>	<b>262.4</b>	<b>269.1</b>	<b>227.2</b>
OLD 2013 submission 2.A.2. CO2 emission	CO2 Gg	323.1	303.8	300.8	318.5	206.0	211.3	178.4
<b>NEW 2014 submission 2.A.2. CO2 Emission</b>	<b>CO2 Gg</b>	<b>298.5</b>	<b>286.0</b>	<b>277.4</b>	<b>303.9</b>	<b>197.3</b>	<b>199.6</b>	<b>170.1</b>
<i>new-old</i>	<i>Gg CO2</i>	<i>-24.6</i>	<i>-17.9</i>	<i>-23.4</i>	<i>-14.6</i>	<i>-8.7</i>	<i>-11.7</i>	<i>-8.3</i>
<i>Difference</i>	<i>%</i>	<i>-7.6%</i>	<i>-5.9%</i>	<i>-7.8%</i>	<i>-4.6%</i>	<i>-4.2%</i>	<i>-5.5%</i>	<i>-4.7%</i>
IEF	Gg CO2 / kt lime	0.725	0.739	0.724	0.749	0.752	0.742	0.748
Average 2005-2012 IEF	Gg CO2 / kt lime	0.739						

## 2.B.2. Nitric Acid

At the end of year 2011 one of the former Nitric Acid plants has been restarted after renovation.. Therefore the activity data and emission of year 2011 was revised in sector 2.B.2. Nitric Acid Production based on direct reporting of companies.

**Table 10.3.3** Change in CO2 emissions from sector 2.B.2

	2011 OLD 2013 submission	2011 NEW 2014 submission	difference	%
Nitric Acid Production (kt)	578.0	<b>588.4</b>	10.38	
N2O emission (Gg)	0.0434	<b>0.0516</b>	0.01	18.95%
2.B.2. emission (Gg CO2 eq)	13.5	<b>16.0</b>	2.55	

## 2.C.1.2 Pig Iron production

Emissions from Natural Gas used in the Blast furnace are reported in subsector 2.C.1.2. Pig Iron. In this year 2010 year data has been revised in IEA Energy Statistics, therefore the emissions of year 2010 are recalculated.

**Table 10.3.4** *Change in emissions from sector 2.C.1.2*

	2010 OLD 2013 submission	2010 NEW 2014 submission	Difference	%
IEA statistics - Nat Gas used in Iron and steel industry (NCV TJ)	1322	1495	173	13%
CO <sub>2</sub> emission in 2.C.1.2 (Gg)	73.80	83.44	9.64	
CH <sub>4</sub> emission in 2.C.1.2. (Gg )	0.0066	0.0075	0.0009	

**2.C.1.4. Coke consumption**

In 2013 submission all the emissions from coke consumption in blast furnace (including emissions from blast furnace gas) were reported in subsector 2.C.1.4.

In present 2014 submission, emissions from blast furnace gas have been separated and reported in 1.A.1.a sector from the year 1990 as blast furnace gas is used in the energy sector in the reality. So, in fact this recalculation is only a reallocation between 2.C.1.4 and 1.A.1.a subsectors.

In 2.C.1.4 subsector, emissions from blast furnace gas are reported as recovery, and are subtracted from CO<sub>2</sub> emissions.

**Table 10.3.5** *Change in CO<sub>2</sub> emissions from sector 2.C.1.4.*

	BY	1990	1995	2000	2005	2008	2009	2010	2011	2012
OLD 2.C.1.4. 2013 submission CO <sub>2</sub> emission	4024.49	2656.8	2280.8	1806.3	1633.4	1649.1	1695.3	1953.3	1947.0	
<b>SZUM Emission from Coke consumption in blast furnace (kt CO<sub>2</sub>)</b>	<b>4163.11</b>	<b>2991.5</b>	<b>2505.5</b>	<b>2016.4</b>	<b>2064.5</b>	<b>2033.3</b>	<b>1862.6</b>	<b>2177.2</b>	<b>2121.2</b>	<b>2064.3</b>
SZUM BFG = SZUM recovery in 2.C.1.4 (kt CO <sub>2</sub> )	3599.51	2586.9	2167.3	1743.9	1782.2	1717.4	1644.6	1976.6	1871.1	1871.3
SZUM emission from Coke consumption in blast furnace NOT recovered (kt CO <sub>2</sub> )	563.60	404.5	338.3	272.4	282.3	315.9	217.9	200.6	250.1	193.0
<b>2.C.1.1. Emission from Coke in Steel production</b>	<b>352.41</b>	<b>286.8</b>	<b>192.6</b>	<b>180.1</b>	<b>181.2</b>	<b>173.0</b>	<b>139.8</b>	<b>174.5</b>	<b>172.7</b>	<b>163.7</b>
<b>2.C.1.4. Emission from coke in pig iron production</b>	<b>211.20</b>	<b>117.7</b>	<b>145.6</b>	<b>92.4</b>	<b>101.2</b>	<b>142.9</b>	<b>78.1</b>	<b>26.1</b>	<b>77.5</b>	<b>29.3</b>
2.C.1.4 diff new/old %	-95%	-96%	-94%	-95%	-94%	-91%	-95%	-99%	-96%	
SZUM Coke consumption difference new/old %	3%	13%	10%	12%	26%	23%	10%	11%	9%	

**2.F.2. Foam**

Suggestion received during the EU MS Support Project (described in chapter 4.8.2.3) has been implemented in 2014 submission.

As it is described in NIR chapter 4.8.3.1 the proportion (%) of HFCs among the blowing agents is needed for the calculation in sector 2.F.2.Foam. In 2013 submission the trend of proportion of HFCs was estimated based on DG Climate study for years between 2003 - 2006 and based on IPCC/TEAP Study for years from 2007. The latter assumes 2015 as the final year of significant HFC use (0% HFC blowing agent/all blowing agents). (For references please see NIR Chapter 4.8.3.1).

During the EU MS Support Project the expert noted that the elimination of HFC blowing agent by 2015 is not realistic and suggested to apply 20% for XPS foams and 10% for PUR foams after 2011 as well. HFC emissions of year 2011 have been recalculated based on this suggestion in sector 2.F.2.Foam.

**Table 10.3.6** Change in proportions of HFC foam blowing agents applied in 2.F.2

		2007	2008	2009	2010	2011	2012	2013	2014	2015
OLD 2013 submission % of HFC blowing agent usage/All blowing agent usage in the case of	XPS products	35.6	31.1	26.7	22.2	17.8	13.3	8.9	4.4	0.0
	PUR products	17.8	15.6	13.3	11.1	8.9	6.7	4.4	2.2	0.0
NEW 2014 submission % of HFC blowing agent usage/All blowing agent usage in the case of	XPS products	35.6	31.1	26.7	22.2	20.0	20.0	20.0	20.0	20.0
	PUR products	17.8	15.6	13.3	11.1	10.0	10.0	10.0	10.0	10.0

**Table 10.3.7** Change in emissions from sector 2.F.2

		2011 OLD 2013 submission	2011 NEW 2014 submission	Difference	%
<b>2.F.2 Foam Actual emissions</b>	Gg CO <sub>2</sub> eq	<b>96.5</b>	<b>101.3</b>	<b>4.8</b>	<b>5.03%</b>
HFC-134a	t	64.3	67.5	3.2	
HFC-227ea	t	4.4	4.7	0.2	

## 2.F.4. Aerosols and MDI

The time series have been recalculated using Tier 2 method applying Eq.3.35 and default emission factor of 50% from GPG, which “means that half of the chemical charge escapes within the first year and the remaining charge escapes during the second year” (chapter 3.7.1. of the GPG).

In addition new calculation method is applied in MDI subsector suggested by the expert of EU MS Support Project organized by DG Climate Action (described in chapter 4.8.2.3). This new method accounts also for emissions from imported products instead of the method applied before, that takes into account only domestically produced MDI-s. The new calculation method is described in detail in chapter 4.8 of the NIR.

**Table 10.3.8** Change in emissions from sector 2.F.4

		1995	1996	1997	1998	1999	2000
2.F.4. OLD 2013 submission	Gg CO <sub>2</sub> eq	NO	NO	NO	NO	0.6	4.8
<b>2.F.4. New 2014 submission</b>	<b>Gg CO<sub>2</sub> eq</b>	<b>14.0</b>	<b>27.9</b>	<b>27.8</b>	<b>27.8</b>	<b>27.7</b>	<b>28.1</b>
<b>Difference</b>	Gg CO <sub>2</sub> eq	14.0	27.9	27.8	27.8	27.1	23.3
	%	100%	100%	100%	100%	4871%	488%

		2001	2002	2003	2004	2005	2006
2.F4. OLD 2013 submission	Gg CO2 eq	6.4	5.6	7.4	8.2	40.3	29.4
<b>2.F.4. New 2014 submission</b>	<b>Gg CO2 eq</b>	<b>28.6</b>	<b>28.7</b>	<b>28.6</b>	<b>28.5</b>	<b>45.1</b>	<b>56.7</b>
<b>Difference</b>	<i>Gg CO2 eq</i>	22.2	23.1	21.2	20.3	4.8	27.3
	%	344%	410%	286%	247%	12%	93%
		2007	2008	2009	2010	2011	2012
2.F4. OLD 2013 submission	Gg CO2 eq	30.1	21.6	17.2	19.6	19.9	
<b>2.F.4. New 2014 submission</b>	<b>Gg CO2 eq</b>	<b>52.6</b>	<b>49.4</b>	<b>42.6</b>	<b>41.7</b>	<b>43.3</b>	<b>46.4</b>
<b>Difference</b>	<i>Gg CO2 eq</i>	22.5	27.8	25.4	22.1	23.4	
	%	75%	129%	147%	113%	117%	

## 2.F.8. SF6 emissions from electrical equipment

In sector 2.F.8. SF6 emissions are calculated using the annual sales data reported by companies (T1 method). Manufacturing emissions are separated based on the data of a company reporting also manufacturing losses. In this year a mistype error in 2011 manufacturing losses data have been discovered and corrected.

**Table 10.3.9** Change in emissions from sector 2.F.8.

		2011 OLD 2013 submission	2011 NEW 2014 submission	Difference	%
2.F.8. Actual emissions from manufacturing	t	0.416	1.889	1.4	354%
2.F.8. Actual emissions from stocks	t	4.705	4.705	0.0	0%
<b>SZUM 2.F.8. Actual emission</b>	<b>t</b>	<b>5.121</b>	<b>6.594</b>	<b>1.4</b>	<b>29%</b>
	Gg CO2	122.3	157.5	35.1	29%

## 2.G. Feedstocks and non energy use of fuels

Feedstock and non-energy use of fuels activity data time series have been recalculated based on IEA Energy Statistics and aggregated into 2.G.1.

Please note that emissions in 2.G. sector are calculated based on individual types of fuels and the default fraction of carbon stored from IPCC 1996 Energy Table 1-5. Therefore time series of emission does not follow the trend of the time series of SZUM TJ NEU and feedstock, but it depends on the contribution of the individual fuels of a given year. Not only the SZUM TJ data, but the contribution of the different fuels has been changed in IEA Energy Statistics compared to the old Hungarian Energy Statistics. This is why the difference between the new and old time series is not the same in CO<sub>2</sub> emissions than in SZUM TJ data.

**Table 10.3.10** Change in CO<sub>2</sub> emissions from sector 2.G

		1985	BY	1986	1987	1988	1989	1990
OLD 2013 submission NEU of fuels and feedstocks	TJ	36739	37241	38800	36183	36239	34675	30202
OLD 2013 submission CO <sub>2</sub> emission from 2.G	Gg CO <sub>2</sub>	544	551	574	535	535	511	445
<b>NEW 2014 submission NEU of fuels and feedstocks</b>	<b>TJ</b>	<b>41523</b>	<b>41487</b>	<b>41987</b>	<b>40952</b>	<b>39631</b>	<b>43435</b>	<b>32927</b>
<b>NEW 2014 submission CO<sub>2</sub> emission from 2.G</b>	<b>Gg CO<sub>2</sub></b>	<b>1020</b>	<b>1034</b>	<b>1046</b>	<b>1037</b>	<b>994</b>	<b>1155</b>	<b>840</b>
<i>Difference</i>	Gg CO <sub>2</sub>	477	483	472	502	459	643	395
	%	88%	88%	82%	94%	86%	126%	89%
		1991	1992	1993	1994	1995	1996	1997
OLD 2013 submission NEU of fuels and feedstocks	TJ	30043	34373	35132	33890	39554	30028	37923
OLD 2013 submission CO <sub>2</sub> emission from 2.G	Gg CO <sub>2</sub>	490	624	566	615	702	586	729
<b>NEW 2014 submission NEU of fuels and feedstocks</b>	<b>TJ</b>	<b>29871</b>	<b>34609</b>	<b>31223</b>	<b>34902</b>	<b>39180</b>	<b>32306</b>	<b>39538</b>
<b>NEW 2014 submission CO<sub>2</sub> emission from 2.G</b>	<b>Gg CO<sub>2</sub></b>	<b>774</b>	<b>896</b>	<b>782</b>	<b>875</b>	<b>1045</b>	<b>796</b>	<b>938</b>
<i>Difference</i>	Gg CO <sub>2</sub>	284	272	215	259	343	210	209
	%	58%	44%	38%	42%	49%	36%	29%
		1998	1999	2000	2001	2002	2003	2004
OLD 2013 submission NEU of fuels and feedstocks	TJ	43642	32898	39587	38139	38633	30398	42944
OLD 2013 submission CO <sub>2</sub> emission from 2.G	Gg CO <sub>2</sub>	800	544	750	654	679	523	744
<b>NEW 2014 submission NEU of fuels and feedstocks</b>	<b>TJ</b>	<b>42080</b>	<b>33471</b>	<b>42012</b>	<b>33301</b>	<b>42892</b>	<b>37180</b>	<b>42248</b>
<b>NEW 2014 submission CO<sub>2</sub> emission from 2.G</b>	<b>Gg CO<sub>2</sub></b>	<b>993</b>	<b>733</b>	<b>991</b>	<b>707</b>	<b>858</b>	<b>668</b>	<b>893</b>
<i>Difference</i>	Gg CO <sub>2</sub>	193	189	242	52	179	145	150
	%	24%	35%	32%	8%	26%	28%	20%
		2005	2006	2007	2008	2009	2010	2011
OLD 2013 submission NEU of fuels and feedstocks	TJ	60763	61072	60199	57447	57284	60243	60500
OLD 2013 submission CO <sub>2</sub> emission from 2.G	Gg CO <sub>2</sub>	1218	1029	1058	920	881	1061	952
<b>NEW 2014 submission NEU of fuels and feedstocks</b>	<b>TJ</b>	<b>62885</b>	<b>63029</b>	<b>66075</b>	<b>60285</b>	<b>55168</b>	<b>58177</b>	<b>60482</b>
<b>NEW 2014 submission CO<sub>2</sub> emission from 2.G</b>	<b>Gg CO<sub>2</sub></b>	<b>1371</b>	<b>1286</b>	<b>1321</b>	<b>1206</b>	<b>1022</b>	<b>1186</b>	<b>1152</b>
<i>Difference</i>	Gg CO <sub>2</sub>	153	257	263	287	140	125	200
	%	13%	25%	25%	31%	16%	12%	21%

### 3. A-C Paint, Solvent and Other Product uses

Recalculation of time series are due to reporting of NMVOC emissions consistent with reporting under Convention on Long-range Transboundary Air Pollution.

As the note of CRF Table 3 states, in sector 3 "The quantity of carbon released in the form of NMVOCs should be accounted for in both the NMVOC and the CO<sub>2</sub>". Therefore the recalculation of NMVOC time series within this sector caused recalculation of CO<sub>2</sub> time series too. 2.2 g CO<sub>2</sub> /g NMVOC default IPCC2006 factor is used for the calculation of CO<sub>2</sub> emission in all the subsectors.

Please note that NMVOC emissions from NFR sector 3C and 3D are aggregated and reported here in CRF sector 3C, because in CRF sector 3D is for reporting of N<sub>2</sub>O use.

**Table 10.3.8** *Change in emissions from sector 3 A-C*

	2013subm. NMVOC	2013subm. CO <sub>2</sub>	2014subm. NMVOC	2014subm. CO <sub>2</sub>	Diff.%	Diff.Gg CO <sub>2</sub>
BY	44.40	<b>130.25</b>	61.70	<b>135.75</b>	4%	5.50
1990	32.50	<b>95.33</b>	52.26	<b>114.98</b>	21%	19.65
1995	17.76	<b>50.37</b>	46.13	<b>101.48</b>	101%	51.10
2000	34.19	<b>97.37</b>	47.01	<b>103.41</b>	6%	6.04
2005	23.34	<b>65.47</b>	40.32	<b>88.70</b>	35%	23.24
2006	20.42	<b>57.51</b>	35.56	<b>78.24</b>	36%	20.73
2007	25.33	<b>71.57</b>	35.35	<b>77.78</b>	9%	6.21
2008	23.44	<b>65.37</b>	36.35	<b>79.96</b>	22%	14.59
2009	17.27	<b>47.91</b>	33.66	<b>74.06</b>	55%	26.15
2010	11.99	<b>32.57</b>	31.98	<b>70.37</b>	116%	37.80
2011	12.65	<b>34.00</b>	33.14	<b>72.90</b>	114%	38.90

### 3.D. Use of N<sub>2</sub>O

It was a planned improvement and recommendation during the review of recent years to investigate if there is import in products containing N<sub>2</sub>O.

In the case of subsector 3.D.5, an expert from the manufacturer of whipped cream chargers(cartridges) containing N<sub>2</sub>O provided an estimate for the share of imported products on the Hungarian market. In 2014 submission this amount has been included in the time series. Please find the comparison table below.

Please find more detailed description and information regarding import of other products containing N<sub>2</sub>O in chapter 5.3 of the NIR.

**Table 10.3.11** *Recalculation in sector 3.D.5 N<sub>2</sub>O use for whipped cream chargers*

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2013 submission (N <sub>2</sub> O kt)	0.0607	0.0558	0.0450	0.0378	0.0386	0.0296	0.0235	0.0231	0.0194	0.0192	0.0202
2014 submission (N <sub>2</sub> O kt)	0.0620	0.0570	0.0460	0.0386	0.0394	0.0302	0.0249	0.0245	0.0214	0.0212	0.0232
Diff.(%)	2.2%	2.2%	2.2%	2.2%	2.1%	2.2%	6.2%	6.3%	10.5%	10.5%	14.7%
Diff. (Gg CO <sub>2</sub> eq)	<b>0.41</b>	<b>0.38</b>	<b>0.30</b>	<b>0.26</b>	<b>0.25</b>	<b>0.20</b>	<b>0.45</b>	<b>0.45</b>	<b>0.63</b>	<b>0.63</b>	<b>0.92</b>

## 10.4 Agriculture sector

Recalculations in the Agriculture sector were made in order to adapt the results of a research project that was finished in 2013. The subject of the project was assigned in line with the ERT's recommendation from the previous annual reviews, namely to get more reliable data on gross energy intake and N-excretion rate for Cattle and Swine and volatile solid excretion rate for Poultry. Replacing these values in the inventory by the new research outcomes resulted in recalculations in the full time-series throughout the agricultural inventory, because the revision affected the emissions from 4.A Enteric Fermentation and 4.B Manure Management as well as the 4.D Agriculture Soils as a consequence of the changes in the annual amount of animal manure nitrogen applied to soils and the N excreted on pasture.

The other significant changes resulting in recalculations are the revision of crop residue parameters as a result of the QA/QC procedures. In the course of the annual QC procedure the source of the applied parameters were examined to fulfill the ERT recommendation to include this information in the NIR. During the process it was revealed that in some cases, mostly when default values were not provided in the IPCC Guidelines, estimated values were applied which could have been replaced by more reliable values taken from the literature or results of laboratory measurements. Now, these values were revised for the CRF sectors 4.D.1.3 and 4.D.1.4.

For the year of 2011 the chronological mean of the guineafowl livestock population was also corrected because of a former calculation error, which resulted in a slight decrease in the poultry livestock population for that year.

Although the revisions affect important values in the inventory, the total impact of these recalculations on the Agriculture sector is not significant. The decrease of total GHG-emissions has a range of 0.3 to 2.9% (Table 10.4.1). The effect is slightly more significant when looking at the CH<sub>4</sub> emissions separately where the percentage increase ranged from 3.0 to 6.8 per cent, while the N<sub>2</sub>O emissions increased in a small extent, ranging from 0.1 to 1.8 per cent.

The reasons for the rising N<sub>2</sub>O emissions are that the revised N-excretion for Swine as well as the revision of the crop residue parameters resulted in slightly higher emissions of this gas. While the cause of the decreasing CH<sub>4</sub> emissions are the lower emissions from Cattle. The recalculations by source categories are as follows:

### 4.A Enteric Fermentation

- Revision of gross energy intake and methane conversion rate for Cattle for the full time-series
- Revision of Poultry livestock population for the year 2011

### 4.B Manure Management CH<sub>4</sub>

- Revision of volatile solid excretion rate for Cattle and Poultry for the full time-series
- Revision of Poultry livestock population for the year 2011

### 4.B Manure Management N<sub>2</sub>O

- Revision of N excretion rate of Cattle and Swine for the full time-series
- Revision of Poultry livestock population for the year 2011

### 4.D Agricultural Soils

#### 4.D.1 Direct Soil Emissions

##### 4.D.1.2 Animal Manure Applied to Soils

- Revision of annual amount of animal manure nitrogen applied to soils for the full time-series

##### 4.D.1.3 N-fixing Crops

- Revision of crop residue parameters for the full time-series

##### 4.D.1.4 Crop Residue

- Revision of crop residue parameters for the full time-series

#### 4.D.2 Pasture Range and Paddock Manure

- Revision of annual amount of animal manure nitrogen applied to soils for the full time-series as a result of the change in the N-excretion of Cattle and Swine

## 4.D.3 Indirect Emissions

## 4.D.3.1 Atmospheric Deposition

- Revision of the volatilized N from animal manure for the full time-series as a result of the change in the N-excretion of Cattle and Swine

## 4.D.3.2 Nitrogen Leaching and Run-off

- Revision of the volatilized N from animal manure for the full time-series as a result of the change in the N-excretion of Cattle and Swine

**Table 10.4.1** Change in the aggregate GHG-emissions from the Agriculture sector due to the recalculations

	BY	1985	1986	1987	1988	1989	1990	1991	1992	
Submission 2013 [Gg CO <sub>2</sub> -eq]	19,044	19,064	18,988	19,079	18,499	17,876	15,477	12,864	11,028	
Submission 2014 [Gg CO <sub>2</sub> -eq]	18,588	18,580	18,538	18,647	18,105	17,517	15,159	12,502	10,711	
Difference [Gg CO <sub>2</sub> -eq]	-456	-485	-450	-432	-394	-359	-318	-361	-317	
Percentage change	-2.4%	-2.5%	-2.4%	-2.3%	-2.1%	-2.0%	-2.1%	-2.8%	-2.9%	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Submission 2013 [Gg CO <sub>2</sub> -eq]	9,824	9,711	9,296	9,458	9,189	9,658	9,927	9,534	9,731	
Submission 2014 [Gg CO <sub>2</sub> -eq]	9,543	9,457	9,106	9,295	9,088	9,569	9,836	9,452	9,647	
Difference [Gg CO <sub>2</sub> -eq]	-280	-254	-190	-162	-101	-89	-91	-81	-84	
Percentage change	-2.9%	-2.6%	-2.0%	-1.7%	-1.1%	-0.9%	-0.9%	-0.9%	-0.9%	
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Submission 2013 [Gg CO <sub>2</sub> -eq]	9,875	9,611	9,769	9,196	9,210	9,237	9,113	8,578	8,531	8,759
Submission 2014 [Gg CO <sub>2</sub> -eq]	9,800	9,531	9,681	9,132	9,167	9,206	9,069	8,539	8,498	8,730
Difference [Gg CO <sub>2</sub> -eq]	-75	-80	-88	-64	-43	-30	-45	-39	-33	-29
Percentage change	-0.8%	-0.8%	-0.9%	-0.7%	-0.5%	-0.3%	-0.5%	-0.5%	-0.4%	-0.3%

## 10.5 LULUCF sector

Recalculations for LULUCF resulted in the complete revision of the time-series.

The effect of these recalculations on total GHG emissions in the LULUCF sector is shown in Table 7.12.1

Reasons for recalculations by land-use categories are as follows:

### 5.A Forest Land

- Including emissions of CO<sub>2</sub> from organic soils for all years for the first time. These emissions were reported previously as not occurring "NO")
- Disaggregation a FL areas under 5.A.1 into 'Forest subcompartments' and 'Others'

### 5.B Cropland

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils

### 5.C Grassland

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils

### 5.D Wetlands

- Emissions from land converted to peat extraction have been reported for the first time;

### 5.E Settlements

- Correction of a calculation error in relation to the reference carbon stocks of mineral soils
- Emissions from 5.E. Wetlands converted to Settlements have been estimated for the first time.

## 10.6 Waste sector

The rationale of the recalculation was to take into account the modernization process in solid waste disposal practices. In previous emission estimations, constant methane conversion factor of 1.0 characteristic for managed disposal sites was applied for the whole time series which turned out to be an overly conservative approach. In 2002, a comprehensive survey of landfill sites was carried out with the support of PHARE. During this project, stock was taken of no less than 2,667 landfill sites of which 1,300 were already closed. Out of the operating 1,367 sites, only 42 met current environmental requirements. It was suggested, though, that further 216 sites could operate temporarily till 2009, and the rest should be closed.

One of the outcomes of the project was a database of landfills with several attributes such as depth, volume, insulation, cover etc. The database contained information among others on controlling, lining, compacting, leachate drainage, biogas collection.

Summarizing the data based on total volume of disposed waste, 15% of the disposal could be classified as managed (controlled), 16% as unmanaged shallow, and the remaining 69% as unmanaged deep.

Based on the above information, we used the following factors:

- 1951-1974: MCF=0.6 for uncategorized SWDS, OX=0.
- 1975-1985: MCF=0.77 representing 15% managed, 16% unmanaged shallow and 69% unmanaged deep disposal. OX=0.
- 1986-2000: MCF=0.77-0.81 keeping the same share of managed/unmanaged sites but gradually decreasing shallow disposal. OX=0
- 2000-2003 MCF=1.0 OX=0
- 2004- MCF=1.0, OX=0-0.1.

As for the oxidation factor, the default zero value was applied for the entire time series. However, it is good practice to use the oxidation value of 0.1 for well-managed landfills. Based on the IPCC GPG, most industrialized countries with well-managed SWDS use 0.1 for OX, which is a reasonable assumption based on available information.

The Hungarian Waste Information System that serves as our main source of information for activity data from 2004 contains two categories for disposals:

D1 Deposit into or onto land, e.g. landfill

D5 Specially engineered landfill, e.g. placement into lined discrete cells which are capped and isolated from one another and the environment

Landfills categorized as D5 can be regarded as well-managed therefore an oxidation value of 0.1 is justified. The following table shows, how the share of disposal into well-managed landfills increased in the last years.

	D1	D5
2004	50.1%	49.9%
2005	41.8%	58.2%
2006	28.1%	71.9%
2007	35.4%	64.6%
2008	31.4%	68.6%
2009	17.0%	83.0%
2010	3.9%	96.1%
2011	5.0%	95.0%
2012	2.6%	97.4%

Also the time series of the amount of disposed waste has been revised for this submission. Instead of using constant values between 1950 and 1974 as previously, the proxy of urban population was applied for this period. For the period 1995-2004, the amount of disposed

waste was harmonized with Eurostat data (and +5% was added to take into account industrial waste disposal).

To summarize the above, our estimates have been changed due to

- Revision of the time series of disposed waste (probably small effect);
- Reallocation of disposal from managed to unmanaged before 2000 (largest effect on emission level);
- Introduction of oxidation factor value of 0.1 for well-managed landfills.

Practically, we did the following. Instead of one, we ran four instances of the IPCC Waste Model, i.e. for shallow and deep unmanaged sites, for managed sites with OX=0 and OX=0.1, and then summed up the results of the four.

The overall effects of the recalculations can be seen in the table below. On average, disposed waste increased by 0.9 per cent, whereas the emissions decreased by 19.4 per cent.

	DEPOSITED WASTE (Gg)			CH <sub>4</sub> EMISSIONS (Gg)		
	OLD	NEW	DIFF	OLD	NEW	DIFF
<b>1985</b>	3893	3893	0.0%	87.30	66.12	-24.3%
<b>1985-87</b>	4018	4018	0.0%	91.30	70.06	-23.3%
<b>1986</b>	4039	4039	0.0%	91.20	70.03	-23.2%
<b>1987</b>	4121	4121	0.0%	95.50	74.03	-22.5%
<b>1988</b>	4102	4102	0.0%	99.70	78.00	-21.8%
<b>1989</b>	3832	3832	0.0%	104.00	81.75	-21.4%
<b>1990</b>	3963	3963	0.0%	107.80	84.88	-21.3%
<b>1991</b>	3340	3340	0.0%	112.00	88.11	-21.3%
<b>1992</b>	3506	3506	0.0%	114.52	90.10	-21.3%
<b>1993</b>	3400	3400	0.0%	117.61	92.55	-21.3%
<b>1994</b>	3571	3571	0.0%	119.84	94.35	-21.3%
<b>1995</b>	3576	3655	2.2%	122.28	96.33	-21.2%
<b>1996</b>	3788	3878	2.4%	124.48	98.28	-21.1%
<b>1997</b>	4023	4124	2.5%	127.00	100.51	-20.9%
<b>1998</b>	4067	4133	1.6%	130.28	103.40	-20.6%
<b>1999</b>	4146	4225	1.9%	133.69	106.35	-20.4%
<b>2000</b>	3847	3923	2.0%	137.27	109.49	-20.2%
<b>2001</b>	3821	3881	1.6%	139.44	111.49	-20.0%
<b>2002</b>	3907	4033	3.2%	141.80	115.28	-18.7%
<b>2003</b>	3966	4166	5.0%	143.20	118.17	-17.5%
<b>2004</b>	3978	4050	1.8%	144.42	120.94	-16.3%
<b>2005</b>	4072	4057	-0.4%	145.52	122.89	-15.6%
<b>2006</b>	3902	3883	-0.5%	145.58	123.66	-15.1%
<b>2007</b>	3477	3462	-0.5%	145.27	123.68	-14.9%
<b>2008</b>	3494	3493	0.0%	143.96	122.95	-14.6%
<b>2009</b>	3439	3463	0.7%	142.48	122.10	-14.3%
<b>2010</b>	2875	2923	1.7%	139.90	120.19	-14.1%
<b>2011</b>	2639	2638	0.0%	132.97	114.34	-14.0%
<b>AVG</b>			<b>0.9%</b>			<b>-19.4%</b>

## 10.7 Planned improvements

Implementation of the 2006 IPCC Guidelines.

## 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 (i.e., Section 7). This decision sets principles to govern the treatment of LULUCF activities; provides a common definition for terms such as “forest”, as well as 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, and/or reference from this Chapter, can be found in Chapter 7 of the NIR.*

As Hungary only elected FM under Art. 3.4, 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 areas covered by trees of forest species in the country that are smaller than 0.5 ha, however, these patches are not surveyed currently.

Concerning **minimum width**, our forests are most often much wider than that, i.e. 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 a 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 above elements of 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” with the exception of , as discussed already in Chapter 7, some forests in each new inventory year that are identified in the reporting year itself (i.e. never before) and are classified as “found forests” (FF). In order that carbon stock change estimation is performed accurately, these forests cannot be included in Forest Land in that year. As we had little information

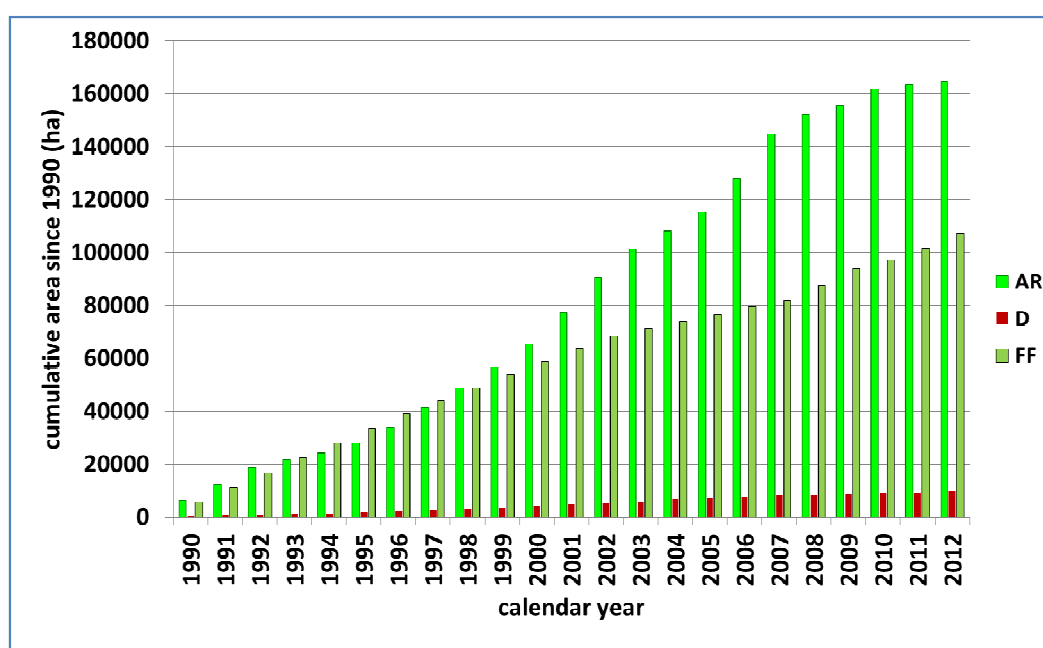
about these forests before, and thus could not demonstrate any human induced activity in these forests, we considered that these forests were not part of FM.

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 are excluded from FM.

In the remaining parts of this section, first we define each activity below. Information on FF can be found both in Chapter 7 and in section 11.2.2 below. Note that for the development of carbon stock changes on FM land some information is discussed in Section 7.3.

The definitions are consistently applied throughout the period 1990-2012. The evolution of the area of the above categories except for FM is demonstrated in Figure 11.1. As shown in this figure, the area of land under FM is slightly decreased by D, and amounts to 1655.4 kha in 2012 (and, when rounding is applied, is about the same as in 2008 through 2012).



**Figure 11.1** The evolution of the cumulative area of AR, D and FF between 1990 and 2011.

#### 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 occurs when the afforestation is deemed “mature” by authorities. 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 171 kha of forest sub-compartments 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 (i.e. in a database of stands), which contains growing stock information, and which is used for the estimation of emissions and removals. This may mean e.g. that the afforestation was not successful. 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 a similar fashion, new AR areas 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 of the inventory year. 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 successfully 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, which are the main causes of the appearance of new forests that are found at a later stage, are regarded as changes that do not comply with the definition of AR (cf. “direct human induced”), therefore, these areas are excluded from the AR category.

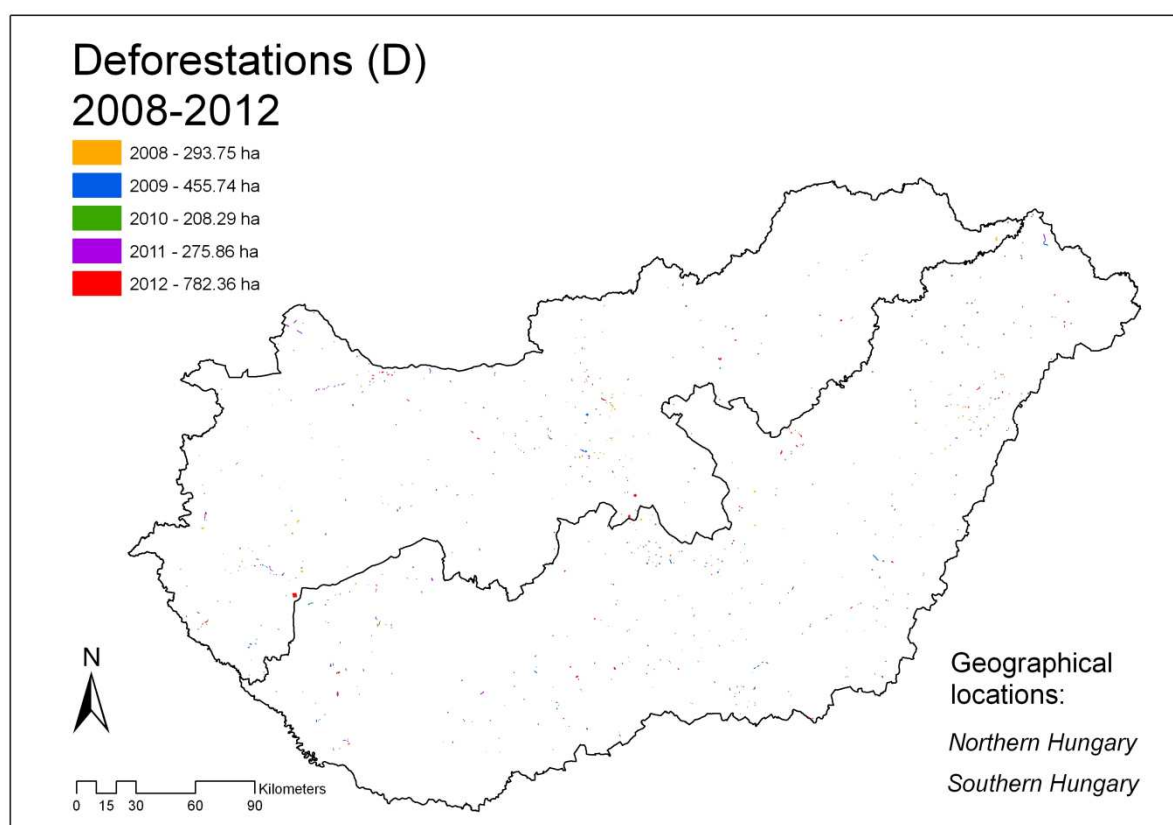
#### **11.1.3.2 Definition and identification of “D since 1990”**

D areas are those that have been clear-cut and removed from areas under forest management in order that the area can be used for non-forestry purposes (i.e., for road building and other land use).

An area enters the D category right away, i.e. in the year, of the clear-cut 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 has only been registered since 2008, i.e. the beginning of the first commitment period under the KP, as it was of no importance for the forest inventory earlier, and the exact location of most deforestations prior to 1 January 2008 are known. Because all deforestations have to be identified under the KP, we set up a system to identify at least the total area of deforestations from all available information even before 2008. This system allows for estimating and accounting for all emissions from deforestations.

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, a sample-based study was conducted 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 7.3.2).



**Figure 11.2** The spatial distribution of deforested land 2008-2012.

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 of 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 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 pre-commercial 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 known 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 thus makes up most of

the area of these reserves, and which surrounds the so called core zone (altogether about 4 kha) where no traditional operation is conducted. 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 of the European Union that involves various protection measures.

The above means that Hungary applies a *broad definition* of “Forest Management” under Art. 3.4 of the KP.

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 known stand each year, all known 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 thus excludes D areas, but also to be noted is that no land has been added to FM since 1989. This holds true for FF (that are also discussed in Chapter 7.2) that are excluded from FM in order to be conservative in the estimation of emissions. FF are forests that are young, that are thus in their intensive growing phase and that are harvested at a low (but unknown) rate. Very little information has been available on these forests, so no “direct human induced activity” can be demonstrated there, which is the main reason for their exclusion. Also, according to standard forest growth and yield theory, the biomass of these forests are carbon sinks, but this holds true for all other pools as well. We are currently not able to estimate the removals by these forests, however, these are not substantial, and excluding these forests from FM results in the underestimation of net removals in non-AR and non-D managed forests.

It is finally also noted here that we report the area of FM, just like for AR and D, as the total area of stands for FM that excludes the area of associated roads etc., see section 11.2.2 below.

#### **11.1.3.4 Separating AR from FM**

As stated above, as soon as site preparation and planting or seeding of propagation material is done, 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. These areas are, however, not considered as FM areas to avoid double counting.

This separation is done, thus, double counting is avoided, and full consistency with the report under the UNFCCC is achieved, by first establishing the area of AR and then developing FM as 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***

The 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) whether 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.
- Both before and in years 2008-2012, all additional changes in the forest area were also identified that were not due to AR or D activities (i.e., FF).
- The total (known) 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.
- By identifying the total forest area, as well as all additions to, and reductions from, the forest area of the previous year, the constant elements (i.e. FM) can be identified. Land under FM was first 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.

The above procedure is done for all geographical locations in the country, which are then summed up at the country level.

The above procedure ensures the consistency of land identification 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. (See also section 7.2.1.)

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 7.2, we report the total "Forest land" area in the CRF table under the UNFCCC, which is more than the total area of all *stands* (the difference being forest roads and other areas not covered by trees). The reason for reporting total forest land area under the UNFCCC 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. (The area of stands includes areas *within* the stands that are occasionally not covered by trees, however, these are reported under the KP.)

We use the area of stands in the KP CRF tables because, for statistical reasons, we only have this type of data for land under AR and D, and it would be impossible to fill in the land transition matrix (Table NIR 2. LAND TRANSITION MATRIX) of the KP CRF with the total area of forests under the various activities. (Many “forest area” statistics that are widely used in the country as official statistics publish this, and often only this, type of area data.) However, the purpose of this matrix is only to demonstrate the consistent accounting of changes between lands under the various KP activities, as well as other land, and the category “Other” is used to allocate non-stand areas, and the consistent use of the area of stands for FM, AR and D alike perfectly achieves this purpose. Additionally, applying these slightly different types of areas does not affect the estimation of emissions and removals at all as it is done with respect to all direct human induced activities affecting these emissions and removals by using volume statistics.

The other reason for the fact that the area of the AR and that of the FM land in the Kyoto CRF tables do not match the total Forest Land area in the CRF tables under the UNFCCC is that we excluded the area of FF from the land under FM, whereas it is included in FL-FL under the UNFCCC.

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* of the NIR. Nevertheless, for reasons of transparency, Table 11.2 below summarizes changes of area under AR and D.

**Table 11.2** *The size of annual land conversions for D (a) and AR (b) for the years of the first commitment period.*

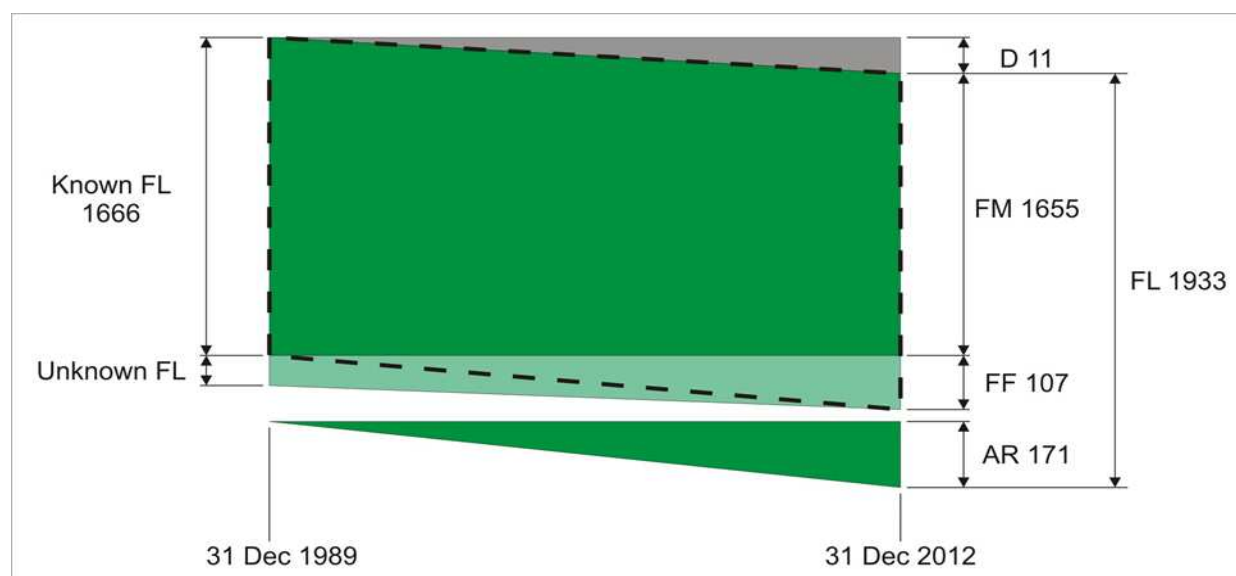
**(a) D**

Inventory year	FL converted to Cropland	FL converted to Grassland	FL converted to Settlement	All conversions from FL to other land use
	Area (ha)			
2008	97	35	162	294
2009	56	103	297	455
2010	59	47	102	208
2011	67	24	185	277
2012	113	389	280	782

**(b) AR**

Inventory year	Cropland converted FL	Grassland converted to FL	Settlement converted to FL	All conversions to FL from other land use
	Area (ha)			
2008	6 674	389	157	7 220
2009	3 177	273	68	3 518
2010	5 429	321	510	6 261
2011	1 413	211	23	1 647
2012	1 012	134	17	1 164

Figure 11.3 below is a draft graphical representation of all changes in the area of all mandatory and elected activities under the KP (using the area of forest stands). These changes represent actual changes (for AR, D and FM) due to the activities under Articles 3.3 and 3.4 of the KP, but also include those processes mentioned above that have resulted in the creation of the FF category.



**Figure 11.3** 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 total areas of sub-compartments (they are slightly different from respective numbers as reported elsewhere due to rounding-off, and so they do not represent official statistics). 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 for the first commitment period are derived as shown by the formulas and data in Table 11.3 (only rounded numbers are used for the entire area of the various activities; for precise numbers, and for data by geographical locations, see the KP CRF table).

**Table 11.3** The evolution of areas under the relevant land use categories under the KP, together with data for total forests and found forests for the first commitment period, as well as the algorithm (i.e. formulas) of developing the data. The area of FM since 1990 in 1990 ("TF89t2") was 1,665,551 ha. The area of FM since 1990 in 2007 was less by the total area of deforestations until then, i.e., 8,128 ha, and was 1,657,422 ha. The table then shows all changes according to the formulas. In the table and the formulas, t1 means the beginning of the year (i.e., the end of the preceding year), whereas t2 means the end of the year. The light yellow color in some cells of the table (with column title "from DB") shows that the data in those cells are taken from the database (i.e., they are the result of other calculations), whereas data in white cells are calculated in this table. All other notations as in Tables 7.3.3 and 7.3.6. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	AREA, ha													
	All Forest Land, forest compartments			D since 1990			FF since 1990			AR since 1990			FM since 1990	
	FL = FM + AR (cum.) + FF (cum.)													
	t1	t2	Δ	t1	Δ	t2	t1	Δ	t2	t1	Δ	t2	t1	t2
	from DB	from DB	t2-t1	from DB	from DB	t1 + Δ	from DB	from DB	t1 + Δ	from DB	from DB	t1 + Δ	FL89t2-D	t1-ΔD
2008	1 890 866	1 903 360	12 494	8 128	294	8 422	82 044	5 567	87 610	151 401	7 220	158 621	1 657 422	1 657 129
2009	1 903 360	1 912 917	9 557	8 422	450	8 872	87 610	6 495	94 105	158 621	3 518	162 139	1 657 129	1 656 679
2010	1 912 917	1 922 108	9 191	8 872	208	9 080	94 105	3 136	97 242	162 139	6 261	168 400	1 656 679	1 656 470
2011	1 922 108	1 927 702	5 594	9 080	277	9 357	97 242	4 224	101 465	168 400	1 647	170 046	1 656 470	1 656 194
2012	1 927 702	1 933 604	5 902	9 357	782	10 139	101 465	5 520	106 986	170 046	1 164	171 210	1 656 194	1 655 412

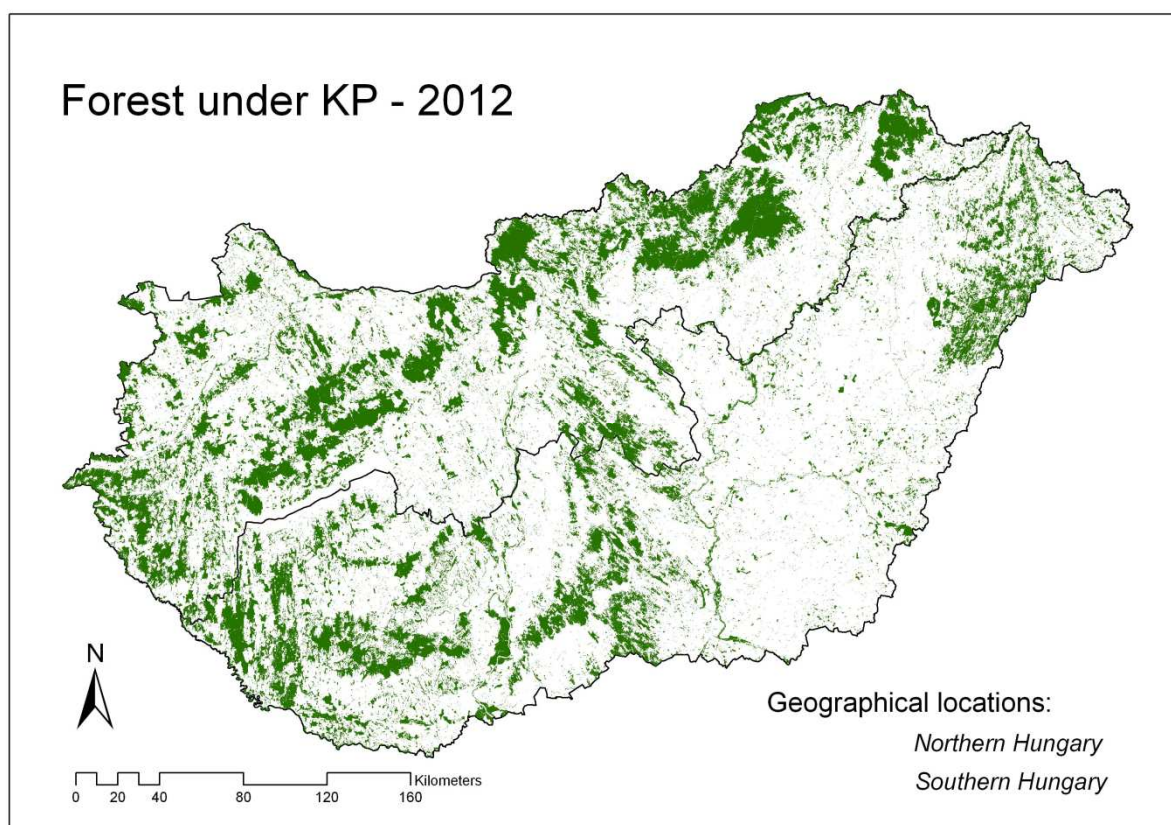
The above calculation demonstrates that (1) all land is accounted for; (2) double counting is avoided; (3) all areas that are not in sub-compartments, but are included in the “forestry area” (i.e., 2,055,632 - 1,933,604 = 122,028 ha in 2012, see Table 11.3) are included in, and accounted for under, “Other” 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 11.4 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 Trans-danubian Mountains (north to Lake Balaton) and the Little Hungarian Plain. The Great Hungarian Plains and the Trans-danubian Hills (South to Lake Balaton) belongs to „South”.

For each year, all area (i.e. each stand) is allocated to one of the above geographical locations, thus, aggregate data (e.g. volume stocks, volume stock changes etc.) for these locations can be developed for each year. The identification system of sub-compartments is made up of three elements which are registered for every sub-compartment. These elements are: the municipality (village, or town), the compartment (a larger piece of forest, e.g. a hillside or a valley) and sub-compartment (which is part of a compartment). The sub-compartment is the basic unit of forest management, its mean size being approximately 4-5 ha. The number of municipalities was 3166 in 1990 and 3193 in 2011, 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 sub-compartment exactly belongs to a municipality, and municipalities are unambiguously mapped, data for the geographical locations can be developed from the above stand level data by appropriately summing them up (see below).



**Figure 11.4** 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 and precise as 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 at its bottom by a 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 the 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, weather 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.

### Methodological issues

The emissions and removals to be reported 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 and precise 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 (i.e. deadwood and litter) for D, however, it only demonstrates that the deadwood, litter, and mineral soil pools are not a source for the aggregated forest area (i.e., AR and FM). Emissions from organic soils only occur on FM land, and are estimated. Also, beginning this year, we estimate emissions from the agricultural lime applications on D land. Thus, Hungary’s report is complete with regard to pools as it covers all carbon pools, with regard to activities as it covers each activity under the KP, and also with regard to all gases to be reported 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 2007-2012, and of the inventory years 2008-2012 (for D). These carbon stocks are directly calculated, using the total *volume stocks* under the various activities, by applying the equations in section 7.2.1 of the NIR (which are basically an adapted version of the relevant equations in the IPCC, 2003, GPG).

This implies the assumption for AR land 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 would take substantial time for a natural vegetation to establish perennial vegetation of substantial biomass, which can rarely happen in Hungary. Removals due to such natural vegetation processes before afforestation are not accounted,

either.

The forests included in the AR category are identified and mapped at the sub-compartment (stand) level. Therefore, stand level information is available as a component of the national forest inventory. Growing stocks and stock changes in the afforested areas are estimated by using field measurements and applying empirical yield tables by appropriate species and site classes.

Other parameters of the equation are 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 (i.e. for young forests) 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. As forests in the AR category are net sinks, this assumption 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 or changes of professional standards (e.g., better complying with site patterns), and it is not possible to keep track of most of these *changes* at the stand level, rather, only at higher administrative units (including the geographical locations). This means that the carbon stock *changes* cannot typically be estimated bottom-up from the stand level, rather, they are calculated from carbon stocks of consecutive years at aggregate levels (i.e. species and species groups), estimated bottom-up from the stand level for categories of AR and D. The same applies to all forests, for which of course the estimation of carbon stocks is split for the two geographical locations.

We highlight here that, consistent with section 7.3, the emissions and removals for lands under FM are indirectly estimated from those of all forest land (FL-FL + L-FL) as well as AR, D and FF where emissions and removals from FL-FL and L-FL exclude carbon stocks of FF found in an inventory year. This procedure is applied, among others, 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., net gains) for FM are calculated using NR of FL under the UNFCCC (FL-FL plus L-FL, excludes NE (net emissions) on deforested land) and NR on land under AR, while excluding FF, according to the following equation, which is also applied in Table 11.4:

$$\begin{aligned} \text{Total NR of forests under FM in 2011} = & \\ & + \text{Total NR of FL-FL in 2011} \\ & + \text{Total NR of L-FL in 2011} \\ & - \text{NR of AR in 2011} \\ & - \text{NR of FF 1990-2010 in 2011} \end{aligned}$$

**Table 11.4** *The development of emissions and removals in FM land, together with the algorithm (i.e. formulas) of the calculations, since 2008. In the table and the formulas, t1 means the beginning of the year (i.e., the end of the preceding year), whereas t2 means the end of the year. The light yellow color in the table shows that the data is taken from the database (i.e., it is the result of other calculations), whereas data in white cells are calculated in this table. All other notations are as in Tables 7.3.3 and 7.3.6. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)*

Inventory year	ΔC of biomass UNDER THE KP, GgCO <sub>2</sub>				
	FL		AR since 1990	FF, all	FM since 1990
	NE	IEF	Δ	NE	Δ
	from DB	NE/area (Gg/ha)	from DB	area * IEF	FL - AR - FF
2008	-4 143	-0.0021769	-1 160	-179	-2 805
2009	-3 216	-0.0016811	-1 154	-147	-1 914
2010	-3 152	-0.0016399	-1 294	-154	-1 704
2011	-2 968	-0.0015396	-1 258	-150	-1 560
2012	-3 838	-0.0019849	-1 234	-201	-2 403

In this calculation we take the same area specific carbon stock changes (i.e., net removals) for FF that can be calculated for the entire forest area, and which is 1.54 tCO<sub>2</sub>/ha for 2011. 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 and site, and that FF are usually younger than that all forests in general, so the increment of FF is larger than that of all forests which leads to an underestimated carbon stock change (sink) for FF.

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 AR, we have also developed a methodology to account for emissions from biomass losses due to AR. This is necessary as some of the afforestations (10.5 kha) take place in former orchards and vineyards. (The majority of the AR area, 1595.5 kha, is former cropland with annual crops and grasslands with no woody vegetation.) To estimate these emissions, we developed a new country-specific value of 6 tdm/ha for the biomass that is assumed to be lost. This biomass, which is a mean value for all types of orchards and vineyards, is assumed to be accumulated in 30 years, so its annual accumulation rate is 0.2 tdm/ha\*yr, which is consistently used in section 7.4.2.1 to account for gains in carbon stocks of perennial crops on croplands.

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 Hungarian forest health monitoring system, called Forest Protection Monitoring and Observation System (in Hungarian: EMMRE), 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 1985-2011. The total emission of carbon from deadwood on a D land is always accounted for in the year of deforestation. For the average amount of deadwood in all Hungarian forests, we used a revised value which is the average of 8.65 m<sup>3</sup>/ha (a value measured in 2010) and

8.92 m<sup>3</sup>/ha (a value measured in 2011), 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 two above values were measured in a monitoring called FPN which is a program to monitor plots in a 4x4km systematic grid. Sampling in this program is done using concentric permanent sample plots. The 16x16km sub-grid of this program is part of the European level forest health monitoring Network (IPC Forest, Forest Focus, Life+ programs & FutMon Project). After a re-assessment of previous estimates, we reduced the value of 11.49 that was used before to 8.78 m<sup>3</sup>/ha.

Total carbon stock changes of the DOM pool in D lands are estimated from the above volume using the methodology of stock change as detailed above (we note here that the assumption that the average wood density of the deadwood is the same that is applied for the woody biomass is a conservative assumption, i.e. it leads to an overestimation of DOM emissions). Total carbon stock changes due to deforestation are obtained by multiplying the average dead wood, conversion factors and the total area of the deforestation.

Considering litter in D, we revised our figures and now rely upon a case study done by Kovacs, Heil and Szabó (2012), which provides a much more thorough estimate of the mean litter content (excluding coarse litter between about 1 cm and 10 cm) of the Hungarian forests than the previous study. In this study it was found that the average amount of carbon in litter is 8.78 t/ha, which means that the mass of carbon stored in the litter pool 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 litter and especially DW are relatively small carbon pools, this simple but anyway Tier 2 approach can be regarded as an accurate and precise methodology as far as practicable.

It is additionally assumed that neither biomass, nor deadwood or litter are produced any more in D areas after the conversion, thus, no removals are accounted for in these pools.

Data and other information is reported in sections 7.3.3.1 and 7.3.3.2.

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.

Non-CO<sub>2</sub> emissions are estimated based on the amount of harvests in the various categories, and the assumption (which is practically true) that all natural forest fires occur on FM land. The methodology is the same as described in the various sections of Chapter 7. For FM, the resulting data are reported in Table 11.5.

**Table 11.5** CO<sub>2</sub> and non-CO<sub>2</sub> emissions from FM land. All notations as in Tables 7.3.3 and 7.3.6. (The table is for demonstration only and may include rounding; for precise numbers, and for data by geographical locations, see the respective CRF tables.)

Inventory year	FM since 1990 all emissions and removals				
	biomass, NE	organic soils	total	burning (CH <sub>4</sub> +N <sub>2</sub> O)	total
	GgCO <sub>2</sub>	GgCO <sub>2</sub>	as in CRF table, GgCO <sub>2</sub>	GgCO <sub>2</sub> eq	GgCO <sub>2</sub> eq
	from DB	from DB	NE of biomass+ organic soils	from DB	all CO <sub>2</sub> + all non-CO <sub>2</sub>
2008	-2 805	16	-2 789	24	-2 765
2009	-1 914	16	-1 898	23	-1 875
2010	-1 704	16	-1 688	25	-1 663
2011	-1 560	16	-1 544	38	-1 506
2012	-2 403	16	-2 386	34	-2 353

Finally, emissions from liming previously deforested land are estimated by using a somewhat simplified methodology given the fact that these emissions are tiny and we do not specifically collect data. The basis of the calculations is that we use the area of D since 1990 subject to agricultural use (i.e., forest land converted to cropland and to grassland, from KP-LULUCF CRF table 5(KP-I)A.2) and multiply it by an average area specific emissions rates that is equal to average per hectare CO<sub>2</sub> emissions from liming in agricultural soils, i.e. cropland and managed grassland. To get this average, the CO<sub>2</sub> emissions from agricultural lime application (from CRF table 5(IV)) are divided by the total area of agricultural lands (from CRF tables 5.A (cropland) and 5.B (grassland)). In order to report the resulting values in C, we convert CO<sub>2</sub> emissions by dividing by 44/12.

#### 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 are used. 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 (2009-2011) was completed recently with the aim to develop more country-specific data for the demonstration, so much new information is available to support 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 earlier, we present the demonstration separately for AR and FM land.

The results of the project were published in a peer-reviewed research journal (Somogyi et al., 2013). This paper is not replicated here, only a summary of the most important arguments is presented. (We note here that an earlier version of the procedure was successfully demonstrated to experts in an international expert meeting, Somogyi, 2006).

The demonstration is based on an approach that stratifies the forest area into strata of rather different emissions or removals so that both the area and specific emission or removal factors of the strata, which mainly depend on the types of forestry operations conducted in the strata, can be identified. Stratification is used to most efficiently use information and data that is available in the country, including forestry statistics that are developed each year. 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.

The strata applied are the following:

- areas where afforestations and reforestations occurred since 1990 on cropland
- areas where afforestations and reforestations occurred since 1990 on grassland (these two strata together covering the entire AR land), land under FM since 1990 where final cutting and artificial regeneration following professional standards occur,
- land under FM since 1990 where final cutting and natural regeneration following professional standards occur,
- land under FM since 1990 where no final cutting occurs, only thinnings and other operations that cause no disturbance to the soil (these last three strata together covering the entire FM land).

The area of each above stratum is known each year. The area of AR on cropland is calculated using the relative amount of land that was cropland and that was grassland prior to the afforestation. There are no reliable estimates of this ratio for historic times, however, sample-based estimates were made for selected years to cover the 1990-2012 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 85%, which corresponds to field experience and consensus of experts in the field. For FM land, there are specific statistics available for the above first two FM strata, from which the area of the third stratum is deducted from the total FM area.

Concerning the emission and removal factors, field measurements (in the above-mentioned project and an earlier one), modelling, literature review, expert judgment and reasoning are applied.

**For the AR land since 1990 that was converted from cropland,** local case studies carried out (Horváth, 2006, Somogyi, 2005 and Somogyi et al. 2011) demonstrated that carbon is hardly ever lost from soils Horváth (2006) earlier used the below equation for carbon stock changes over time,  $t$ , after the afforestation on cropland:

$$\Delta C_t = 43.5 \cdot (1 - e^{-0.016 \cdot t})$$

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. The

field measurements by Somogyi et al. (2013) re-assessed the validity of this model using a paired-plot series of cases studies in fast-growing Black locust (*Robinia pseudoacacia*) stands, and in slow-growing sessile oak (*Quercus petraea*) afforestations, representing typical fast and slow growing species of afforestations in the past several decades. Carbon stock changes over age were 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, which were those resulting from the equation of Horvath (2006). 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. (2013) 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.

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:

$$\Delta C_t = 32.9 \cdot (1 - e^{-0.015t}) - 29.0 \cdot (1 - e^{-0.046t})$$

We note that, as opposed to afforestations on former croplands, we continue to estimate emissions even after the 20 year default period in order to be conservative.

Concerning land under FM since 1990 where final cutting and artificial regeneration following professional standards occur, artificial regeneration 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. According to IPCC default factors (Table 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, for which we assume the mean value (Table 11.6) 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 7.4 for details).

**Table 11.6** *The distribution and carbon stock of forest soils in Hungary by climate and soil types (for details, see section 7.4).*

Soil characteristics	WD HAC	CD HAC	WD sandy	CD sandy	Total
Distribution of area (%)	35.71%	53.59%	0.86%	9.85%	100.00%
SOC <sub>ref</sub> (tC/ha)	48	58	15	21	<b>50.42</b>

Based on the above loss rate and reference carbon stock, the overall loss is equal to  $50.42 \cdot 0.18 = 9.1 \text{ tCha}^{-1}$ . 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 the reporting year of 2011, we use a revised specific carbon loss for this stratum. This revision is based on the recent study (Somogyi et al. 2011, Somogyi et al., 2013) that was already mentioned above. In this study, several case studies were conducted to estimate 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, whereas intensively growing poplars were used to represent fast growing species. According to results, there are indeed areas where carbon stocks decrease after afforestation, with a rather high variability.

There are, however, several other factors to consider, too. One is that increase also occurs 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 m<sup>3</sup> of above-ground wood volume (this value was only chosen for the sake of demonstration). If basic wood density is 0.5 t m<sup>-3</sup> (a good approximation of national average), then above-ground biomass is 160 t ha<sup>-1</sup>, which translates to 80 t Cha<sup>-1</sup>. After applying a root-to-shoot ratio of 0.25 (that we consistently apply for the belowground biomass pool, see above), 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. 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 set depth of 30 cm is rather 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 by Somogyi et al., 2013). Therefore, estimates and demonstration for the 30 cm layer may not have to do anything with actual processes.

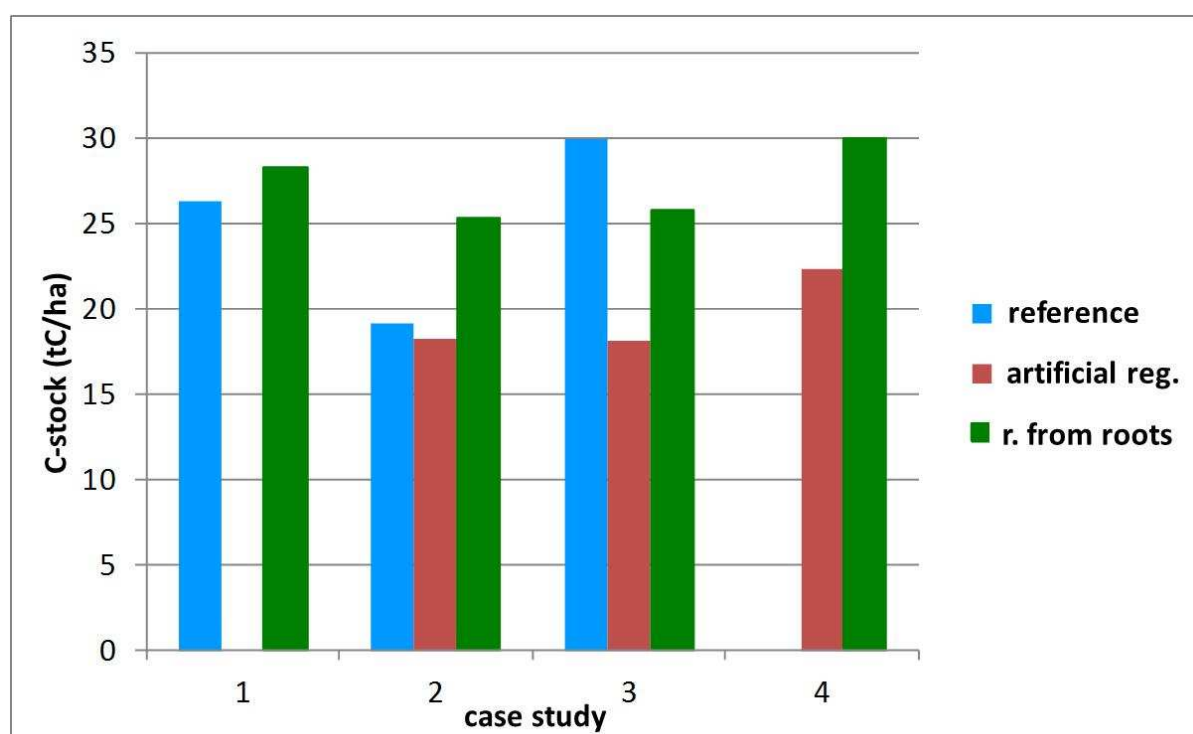
The above would call for a substantial reduction of the rate of the specific emissions due to human induced disturbances that is applied in this demonstration. In order to stay conservative, however, we keep this rate at a still highly conservative value of 5 t Cha<sup>-1</sup> until further, although 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.)

We note here that the area statistics for this stratum are for the entire forest area, and they 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.

For land under FM since 1990 where harvesting and natural regeneration is made following professional standards, natural regeneration 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 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>.

Here we again present one specific result from the above mentioned research project (Figure 11.7). 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, which is considered one form of natural regeneration in Hungary, 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 11.5** 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).*

Finally, the stratum of all other land under FM since 1990, i.e. those that are between regeneration and the beginning of the subsequent regeneration and final cutting, that may only be affected by normal silvicultural operations such as thinnings, and which is by far the biggest one by area, 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, which is based on an extensive literature review (see below and Somogyi et al., 2013), is a net removal of 0.05 tCha<sup>-1</sup>.

The summary of the data for AR and FM, and all of the above strata for 2012 are found in Table 11.7. All data in the table should only be regarded as values whose only role is to establish the sign of the net results for the demonstration. In other words, the estimated values, including the total carbon stock change value, 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 11.7** The area, emission and removal data for the various AR and FM strata and for their total in 2011. See text for details.

Forest Land Stratum under the KP		Estimated area (kha)	Emission (+) and (tC ha <sup>-1</sup> )	Total emissions (+) (ktC)
Land under AR since 1990	that was converted from cropland	$171.2 \times 0.86 = 147.2$	estimated using functions by Horváth, 2006 (corrected for 0-30 cm depth) and Somogyi et al. 2011	-49.0
	that was converted from grassland	$171.2 \times 0.14 = 24.0$		0.6
	<b>Total</b>	<b>171.2</b>	<b>-0.28</b>	<b>-48.4</b>
Land under FM since 1990	where final cutting and artificial regeneration is made following professional standards	18.0	5	90
	where harvesting and natural regeneration is made following professional standards	4.8	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	$1655.4 - 18 - 4.8 = 1632.6$	-0.05	-81.6
	<b>Total</b>	<b>1655.4</b>	<b>0.0051</b>	<b>8.4</b>

The result of the calculations is a considerable sink for AR land, and a very tiny source for FM. However, values have been meandering around zero in the last few years, so it can safely be stated that, overall, the mineral soils of forests of the FM land are not a source.

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 FM land, the assumed value of 5 tCha<sup>-1</sup> is the absolute maximum that one could assume based on the idea of completely converting forest to any another land use. 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 do not occur in forests, thus, total carbon stock losses must be much smaller in forest land remaining forest land than converting a forest land to cropland. Also, there are many types of artificial regeneration applied, including ones that do not involve any types of 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  $5 \text{ tCha}^{-1}$  is with high probability a rather high overestimation, and it is applied 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, calculated using the total non-AR and non-FF areas, and the total annual area of regeneration, is about  $(1,912-162.94) \text{ kha} / 19.2 \text{ kha} = 86.2$  years. (This value does not show large volatility.) Assuming an annual soil carbon stock increase of  $0.05 \text{ tCha}^{-1}$  in these areas after regeneration is equivalent to assuming a total sequestration of  $4,23 \text{ tCha}^{-1}$  for this total average rotation period, which is only about 85% of the emissions ( $5 \text{ tha}^{-1}$ ) that is assumed for these areas if they are regenerated artificially. Thus, the assumed values suggest a net loss of carbon from this stratum. Note, however, that there are other areas where regeneration does not involve emissions from soils.
- The removal value of  $0.05 \text{ tCha}^{-1}$  for a stratum under FM is also a rather conservative estimate 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  $0.05 \text{ tCha}^{-1}$  rate. The Somogyi et al. (2013) 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  $200 \text{ kg C ha}^{-1}\text{yr}^{-1}$ .” (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  $0.05 \text{ tCha}^{-1}\text{yr}^{-1}$ , i.e.  $50 \text{ kg C ha}^{-1} \text{ yr}^{-1}$ , 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 the rate or removals by forest soils. However, this attempt, which included the carbon stock of 12 stands of similar site in a chronosequence proved to be inconclusive due to the low sampling intensity relative to the high variation in soil parameters (Somogyi et al. 2013). According to a more intensive study conducted in Thuringen (Germany), where soil and forest conditions are similar, an annual rate of change in forest soils of  $0.05 \text{ tha}^{-1}$  can be detected by a  $4 \times 4 \text{ km}$  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 aim, 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 identified such processes broadly 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.

### ***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 (and reach just under 9 tCha<sup>-1</sup> for both pools as suggested by our monitoring programs detailed below as well as Heil, Kovacs and Szabó, 2012), 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.*).

According to the most recent estimates, the amount of the standing deadwood in Hungary has increased by just under 1% during the period 2000-2005 (Figure 12 of Somogyi-Zamolodchikov, 2007, which is based on data of the National Forestry Database). 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.

Just like for AR land, the above demonstration for FM land 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)**

We recalculated (i.e., calculated for the first time) both the emissions from organic soils on FM land, and emissions from lime application on D land. The estimation of emissions from organic soils on FM land involved the estimation of the area of forests on organic soils as described in Section 7.3.1.2.2. For emissions from lime application on D land, see Section 11.3.1.1.

As a follow-up to the comment of the ERT in 2012, we recalculated some data for D according to the following table (the reason for the recalculation being that, instead of the final value of calculations, and intermediate one was entered in the CRF table):

Year, category and estimate recalculated	Old value	New value
<b>2008 - KP.A.2 Deforestation/ Carbon stock change/ Southern-Hungary</b>		
Change in carbon stock/ Carbon/ Below-ground biomass - Losses	-0.65	<b>-0.58</b>
Change in carbon stock/ Carbon/ Above-ground biomass - Losses	-2.60	<b>-2.31</b>
<b>2008 - KP.A.2 Deforestation/ Carbon stock change/ Northern-Hungary</b>		
Change in carbon stock/ Carbon/ Below-ground biomass - Losses	-0.57	<b>-0.90</b>
Change in carbon stock/ Carbon/ Above-ground biomass - Losses	-2.29	<b>-3.60</b>

For other details, see Chapter 7.3.6.

### 11.3.1.5 Uncertainty estimation

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. This section describes methods and results of uncertainty estimation both for categories under the Kyoto Protocol and those under the UNFCCC as it seems more practicable to describe similar systems once and highlight differences.

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 in order that the inventory can be developed so that the more important and/or less certain estimates can be improved first. 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, based on the magnitude of their size, 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 (such events, however, have not occurred in our forests in the last decades).

We note here that the uncertainty of certain forest characteristics, e.g. the size of the area of land under the various activities, is rather 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 can be regarded as conservative and may in this sense result in an underestimation of removals and overestimation of emissions as demonstrated in section 11.2.2. above.

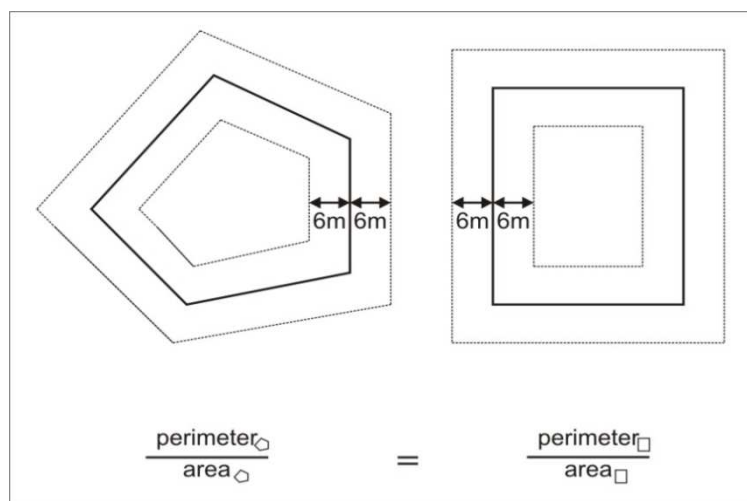
It became possible for us to conduct a new uncertainty estimation in 2012. This analysis replaces the uncertainty estimation that we reported earlier. It is built on the above list, and it focuses on source and sink categories in the various activities under the Kyoto Protocol. We assume that the uncertainty estimates developed apply to the respective categories under the UNFCCC. This year, we submit the same analysis as in 2013.

The analysis involves calculations of the emissions and removals at the same levels that are used for the GHG inventory, but, in order to obtain information on the error distributions, we applied some calculations at the stand level (see below), too. The quantifiable uncertainties were calculated using a Monte Carlo analysis. The methods of the uncertainty calculations are demonstrated for forest area, then carbon stock changes by pool and emissions by sources.

### **Forest area**

All estimates are related to the area of the various categories, therefore, it seemed important to estimate the error of area identification. This was done by assuming that the borders of the stands as polygons have a maximum error of 6 m (see Figure 11.6 below). A dedicated study showed that, in calculating the error of the size of the area, it did not matter if we used actual polygons or rectangles of the same size (see again figure below). Thus, we could simulate the errors of the area for all stand assuming a normal distribution and using the mean size of the areas as the mean of the distribution, and the maximum and minimum areas as their range.

**Figure 11.6.** Possible largest and smallest area of a stand if perimeters are assumed to be off (thin lines) from those in the database (thick lines) by a maximum 6 m in both directions (left), and the rectangular actually used to estimate the error of the area (right).



### **Biomass pools**

With respect to the estimation 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. The forest inventory was designed to collect data on a stand level, but to provide most accurate estimates at various aggregate levels, and mainly for forests under FM.

To be noted is the fact that, in order to achieve efficiency and practicability, different levels of

accuracy are applied to the survey of individual sub-compartments depending on the age of the trees and the estimated amount and value (quality) of the growing stock in most forests. However, due to needs for accurate emission and removal estimates from D, the monitoring system has been developed since 2008 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, and the model 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 and precise as far as practicable, but with somewhat higher uncertainty than for land under other activities. Also, as mentioned before, a low root-to-shoot ratio is assumed for the AR stands, thus, below-ground biomass values are most probably underestimated. As long as AR land is a net sink, this yields a conservative estimation.

Concerning the estimation under the UNFCCC, a different method should have had to be applied as it is not known exactly which stands are included in the L-FL category. However, we focused on the estimation of the uncertainty of the estimates at the activity level under the Kyoto Protocol, and assume that similar uncertainties will apply to both AR and L-FL.

For all activities, we have calculated the uncertainties of the GHG inventory in the MC analysis using aggregated volume stock changes and error estimates at the *species level* (i.e. for 22 subdivisions). The estimation of the errors at this level using stand level volume stock information is described in a dedicated document that can be found at [http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/supplementary\\_inf\\_ERT/forest-db.html](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/supplementary_inf_ERT/forest-db.html). In essence, the National Forestry Database (NFD) contains a volume stock per unit area ( $\text{m}^3/\text{ha}$ ) data for each species of each of the circa 400 thousand stands. For each species, total volume stock is obtained by multiplying this species data with the area of the stands. The uncertainty of the total volume stock of a species thus depends on the volume stock per unit area and the area data. The uncertainty of the volume stock per unit area data arises from sampling errors (when field surveys are made once in 10-12 years) and errors using yield tables (when volume stocks are updated for each year between consecutive surveys). The size of the two errors combined was assessed in a study using detailed field measurements in 642 stands. Based on this analysis we have concluded that for stands of each slow growing species, the uncertainty of the volume stock per unit area for *individual stands*, which was typically between  $\pm 30\text{-}40\%$  for stands older than 40 years, will be assumed to be  $\pm 40\%$  for such stands, and will be  $\pm 80\%$  for stands younger than 40 years. For one fast growing species, i.e. Black locust, similar values were assumed for ages above 20 years and below, respectively. The resulting overall uncertainty at the species level can be found in Table 11.5.

For basic wood density, we used a  $\pm 10\%$  uncertainty based on Somogyi (2008), assuming a triangular distribution whereas default data in Table 3A.1.8 of Annex 3A.1 of the GPG for LULUCF 2003 and Table 4.3 of the IPCC 2006 GL and triangular distributions were used for other factors such as root-to-shoot ratio and carbon fraction.

### Deadwood and litter

Emissions from these pools are estimated for deforested areas. The mean amount of deadwood ( $8.78 \text{ m}^3/\text{ha}$ ) and its uncertainty ( $\pm 8\%$ ) was estimated using a statistical

sampling, the methodology of which is described in the following document:

[http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti\\_igazgatosag/erdeszeti\\_szakteruletek/monitoring/EMMRE\\_20\\_eve/fmo-eng.html](http://www.nebih.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/erdeszeti_szakteruletek/monitoring/EMMRE_20_eve/fmo-eng.html). Other parameters to estimate carbon content are the same as for biomass above.

The amount of carbon stored in the litter pool (8.78 t C/ha) and its uncertainty (-94/+308 %, a rather asymmetrical interval) was derived by the literature review and expert judgment by Heil et al. (2012).

## Soil

As reported above, emissions from soils are only estimated for deforested land. For the area of this land, the same uncertainty was assumed as above.

The uncertainties of the  $F_{LU}$ ,  $F_I$  and  $F_{MG}$  factors were taken from Table 3.3.4 of the GPG. For the uncertainty of the  $SOC_{ref}$ , country-specific values were used (Zsembeli et al. 2011, see Table 11.5). For all these factors, triangular distributions were assumed.

The estimation of  $N_2O$  emissions due to disturbances required the application of C:N ratio as well as the EF1 emission factor. The uncertainty of the former was set to be between -48.6/+172.5% (i.e. a rather asymmetrical range) based on the expert judgment by Heil et al. (2012). The uncertainty of the EF1 factor (80/+380 %, again, very asymmetric) was taken from pages 3.47-3.48. of the GPG. Because of these asymmetrical values, it was not possible to apply the triangular distributions, and, as the emissions are small, we applied Approach 1 error propagation methods to estimate the resulting uncertainties.

## Burning slash and wildfires

The estimation of the uncertainty of emissions from burning slash and wildfires applied the formulas as reported in section 7.3.1.3 above. Preliminary estimates of uncertainties of the various factors were provided by Rumpf (2012). As the fraction of harvested volume burnt could not be modeled using a triangular distribution, the error propagation method was used to estimate its effect. Based on expert judgment, the uncertainty of the fraction of the amount burnt in wildfires is estimated to be  $\pm 20\%$  (Debreceni 2011). The uncertainty of factors that are the same way necessary to calculate biomass carbon as with other categories is as above. Finally, the uncertainty of the emission ratios are from Table 3A1.15 of the Annex of the GPG (CH<sub>4</sub>:  $\pm 25\%$ , CO:  $\pm 33.3\%$ , N<sub>2</sub>O:  $\pm 28.6\%$ , NO<sub>x</sub>:  $\pm 22.31\%$ ), whereas that of the N/C is assumed to be  $\pm 100\%$  based on the default value of Table A1-1 of Annex1ri of the IPCC Revised 1996 Guidelines. The uncertainty of the fraction oxidized on site was set to  $\pm 10\%$ . Concerning distributions, normal distribution was assumed for the volume data, whereas triangular distributions were assumed for the emission factors.

All input data that were applied for the Monte Carlo analysis are summarized in Table 11.8.

**Table 11.8** *Input data for the uncertainty analysis.*

pool	gas	variable	KP category	UNFCC category	assumed type of the pdf of errors	uncertainty value	source
area	CO <sub>2</sub>	area of forest subcompartment	AR, D, FM	L-FL, FL-L, FL-FL	normal	+/- 6 m in border lines	expert judgement (Mezei L., 2011)
biomass	CO <sub>2</sub>	m <sup>3</sup> /ha values of tree species on forest subcompartment level	AR, D, FM	L-FL, FL-L, FL-FL	normal	+/- 40 % (stands older than 40 years old), +/- 80 % (younger stands)	analyses of forest planning sampling data
	CO <sub>2</sub>	wood density	AR, D, FM	L-FL, FL-L, FL-FL	triangular	+/- 10 %	Somogyi (2008)
	CO <sub>2</sub>	carbon fraction	AR, D, FM	L-FL, FL-L, FL-FL	triangular	+/- 4.17 % (deciduous species), +/- 7.84 % (conifers)	GL for LULUCF 2006 Table 4.3
	CO <sub>2</sub>	root-to-shoot ratio	AR, D, FM	L-FL, FL-L, FL-FL	triangular	-50 / +100 %	GPG for LULUCF 2003 Annex 3A.1 Table 3A.1.8
	CO <sub>2</sub>	carbon content of orchards and vineyards	AR (losses)	L-FL (losses)	triangular	+/- 40 %	expert judgement (Juhos and Tókei 2012)
deadwood	CO <sub>2</sub>	area of forest subcompartment	D	-	normal	+/- 6 m in border lines	expert judgement (Mezősi 2011)
	CO <sub>2</sub>	m <sup>3</sup> /ha value on country level	D	-	normal	+/- 8 %	data of National Forest Monitoring and Observation System
	CO <sub>2</sub>	carbon fraction	D	-	triangular	+/- 10 %	GPG 2003 Appendix 3A.1 Table 3a1.4
	CO <sub>2</sub>	wood density	D	-	triangular	+/- 10 %	Somogyi (2008)
litter	CO <sub>2</sub>	t C/ha	D	-	N/A	-94/+308 %	expert judgement (Heil et al. 2012)
slash burning	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	m <sup>3</sup> /ha values of tree species on forest subcompartment level	AR, D, FM	FL-FL	normal	+/- 40 % (stands older than 40 years old), +/- 80 % (younger stands)	analyses of forest planning sampling data
	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	burned slash fraction on forest subcompartment level	AR, D, FM	FL-FL	N/A	-100 % / +98-269 % (depending on the tree species; in the case of beech +2608 %, however, it means very little absolute volume value because only 1000 m <sup>3</sup> beech wood is burnt on site on country level)	expert judgement (Rumpf 2012)
wildfires	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	burned fraction of the total standing volume on subcompartment level	AR, FM	FL-FL	triangular	+/- 20 %	expert judgement (Debreceni 2011)
slash burning, wildfires	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	fraction oxidized on site	AR, D (slash burning only), FM	FL-FL	triangular	+/- 10 %	expert judgment (Tobisch, 2012)
	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	carbon fraction	AR, D (slash burning only), FM	FL-FL	triangular	+/- 4.17 % (deciduous species), +/- 7.84 % (conifers)	GL for LULUCF 2006 Table 4.3
	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	wood density	AR, D (slash burning only), FM	FL-FL	triangular	+/- 10 %	Somogyi (2008)
	CH <sub>4</sub> , CO, N <sub>2</sub> O, NO <sub>x</sub>	emission ratio	AR, D (slash burning only), FM	FL-FL	triangular	CH <sub>4</sub> : +/- 25 %, CO: +/- 33.3 %, N <sub>2</sub> O: +/- 28.6 %, NO <sub>x</sub> : +/- 22.31 %	GPG 2003 Annex 3A1 Table 3A1.15
	N <sub>2</sub> O, NO <sub>x</sub>	N/C ratio	AR, D (slash burning only), FM	FL-FL	triangular	+/- 100 %	GPG_1996annex1ri, Table A1-1
soil	CO <sub>2</sub> , N <sub>2</sub> O	FLU, FI, FMG on country level	D	FL-L	triangular	FMG: +/- 9 %; FLU: +/- 10 %; FI: +/- 7 %	GPG Table 3.3.4 and area of climate and soil types (Zsembeli et al. 2011)
	CO <sub>2</sub> , N <sub>2</sub> O	SOCref on country level	D	FL-L	triangular	WD-HAC: +/- 13 %; CD-HAC: +/- 16 %; WD-SANDY: +/- 20 %; CD-SANDY: +/- 38 %	study of Zsembeli et al. (2011)
	N <sub>2</sub> O	C/N ratio in forest soils	D	FL-L	N/A	-48.6 / +172.5 %	expert judgement (Heil et al. 2012)
	N <sub>2</sub> O	EF1	D	FL-L	N/A	-80 / +380 %	GPG p. 3.47-3.48

## Results

We report all results in Table 11.9 below. According to the results, the combined uncertainty of the net removal estimates of categories under the KP amount to between about  $\pm 15\%$  (for D) and  $\pm 30\%$  (for FM), and the uncertainty of the activity data (volume stock change, volume and area) is the source of roughly the half of all uncertainties except for FM where it has a larger share. For AR, for which we provided uncertainty estimates in our previous submissions, we estimated somewhat higher uncertainties in this study which is partly a result of considering more sources of uncertainties and using all available data instead of models.

As total emissions from D are smaller than those from AR and FM by a factor of two, the uncertainty of emissions from D is considered satisfactory. The confidence interval of the emissions from D is rather asymmetrical mainly due to the asymmetrical confidence interval of the uncertainty of the carbon stock change estimate from litter. The overall uncertainty of the emissions from D is also mainly affected by the litter uncertainty, but the biomass and soil uncertainties are also considerable. Although the factors used to estimate emissions from litter and soil can be considered country-specific, they are mainly based on expert judgment (Heil et al. 2012) but also partly representative sampling (Zsembeli et al. 2011).

For both AR and FM, the combined uncertainty practically comes from that of the biomass stock change due to the fact that other emissions are very small. Concerning the uncertainty of the biomass stock change estimates, they are affected by the uncertainty of the area, volume stock change, wood density, root-to-shoot ratio and carbon fraction estimates. Of all these, the uncertainty of the area is very small (0.03 % at the country level), and that of the wood density, root-to-shoot ratio and carbon fraction cannot really be affected by any policy, nor it is practicable to obtain more accurate estimates.

The uncertainty of the volume stock change at the stand level is due to sampling errors, measurement errors, and errors resulting from the use of yield tables, and is taken to be  $\pm 40\%$  as reported above. The uncertainty of the volume stock changes of the various species or species group still varies from 15-290%, but is much smaller overall. Nevertheless, the results suggest that efforts should be taken to reduce the uncertainty of data at the stand level. The distribution of the uncertainty could also be studied in relation to the age as well as other characteristics of the stands (e.g. the mixing rates, heterogeneity of the stand structure etc.)

**Table 11.9** Aggregate results of the Monte Carlo analysis for AR (a), D (b) and FM (c).**(a) AR**

Sink/source	Gas	E/R	E/R	Activity data		Emission factor		Combined		Contribution to overall uncertainty
		Gg	GgCO <sub>2</sub> eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
biomass (stock-change)	CO <sub>2</sub>	-1256.35	-1256.353	-12.1	11.5	-17.65	11.83	-21.4	16.5	>99
slash burning	CH <sub>4</sub>	0.015256	0.320375	-3.2	3.1	-66.52	97.75	-66.6	97.8	<1
slash burning	CO	0.133504	0	-3.2	3.1	-67.32	98.35	-67.4	98.4	<1
slash burning	N <sub>2</sub> O	0.000105	0.032513	-3.2	3.1	-83.34	110.66	-83.4	110.7	<1
slash burning	NO <sub>x</sub>	0.003792	0	-3.2	3.1	-83.84	110.46	-83.9	110.5	<1
wildfires	CH <sub>4</sub>	0.03601	0.756219	-18.4	19.3	-18.09	24.00	-25.8	30.8	<1
wildfires	CO	0.315125	0	-18.4	19.3	-25.81	30.39	-31.7	36	<1
wildfires	N <sub>2</sub> O	0.000248	0.076745	-18.4	19.3	-76.11	87.80	-78.3	89.9	<1
wildfires	NO <sub>x</sub>	0.008951	0	-18.4	19.3	-75.90	90.46	-78.1	92.5	<1
<b>TOTAL</b>			<b>-1255.167</b>							<b>100</b>

**(b) D**

Sink/source	Gas	E/R	E/R	Activity data		Emission factor		Combined		Contribution to overall uncertainty
		Gg	GgCO <sub>2</sub> eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
Deadwood	CO <sub>2</sub>	2.397653	2.397653	-8.7	9.2	-9.52	12.10	-12.9	15.2	0.045
litter	CO <sub>2</sub>	8.879759	8.879759	-2.3	2.3	-93.67	307.49	-93.7	307.5	71.385
biomass (stock-change)	CO <sub>2</sub>	45.75307	45.75307	-9.9	10.5	-11.14	15.71	-14.9	18.9	22.245
slash burning	CH <sub>4</sub>	0.005822	0.12227	-9.2	10	-51.18	93.27	-52	93.8	0.002
slash burning	CO	0.050951	0	-9.2	10	-51.79	93.57	-52.6	94.1	0.000
slash burning	N <sub>2</sub> O	4E-05	0.012409	-9.2	10	-63.84	101.71	-64.5	102.2	0.000
slash burning	NO <sub>x</sub>	0.001447	0	-9.2	10	-64.04	101.61	-64.7	102.1	0.000
soil	CO <sub>2</sub>	12.99638	12.99638	-2.3	2.3	-29.91	19.46	-30	19.6	6.192
soil	N <sub>2</sub> O	0.000833	0.258115	-4.9	4.8	-57.79	552.18	-58	552.2	0.131
<b>TOTAL</b>			<b>70.420</b>							<b>100</b>

**(c) FM**

Sink/source	Gas	E/R	E/R	Activity data		Emission factor		Combined		Contribution to overall uncertainty
		Gg	GgCO <sub>2</sub> eq.	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	CI_lower, %	CI_upper, %	%
biomass (stock-change)	CO <sub>2</sub>	-1560.13	-1560.134	-28.3	27.1	-13.83	11.91	-31.5	29.6	>99
slash burning	CH <sub>4</sub>	1.118271	23.4837	-0.7	0.7	-39.09	39.09	-39.1	221.3	<1
slash burning	CO	9.785924	0	-0.7	0.7	-39.49	39.49	-39.5	221.4	<1
slash burning	N <sub>2</sub> O	0.007688	2.383262	-0.7	0.7	-48.79	48.79	-48.8	223.4	<1
slash burning	NO <sub>x</sub>	0.277964	0	-0.7	0.7	-49.20	49.20	-49.2	223.3	<1
wildfires	CH <sub>4</sub>	0.486317	10.21265	-6.7	5.8	-20.64	20.91	-21.7	22.3	<1
wildfires	CO	4.255726	0	-6.7	5.8	-27.29	27.49	-28.1	28.1	<1
wildfires	N <sub>2</sub> O	0.003343	1.036439	-6.7	5.8	-78.01	78.08	-78.3	87.7	<1
wildfires	NO <sub>x</sub>	0.120882	0	-6.7	5.8	-78.31	78.39	-78.6	86.2	<1
<b>TOTAL</b>			<b>-1523.018</b>							<b>100</b>

**11.3.1.6 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. In order not to underestimate emissions and overestimate removals, a highly conservative approach is applied in all steps of the inventory whenever 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 inter-annual variability of the physical processes. Therefore, the estimated emissions and removals are partly, but not completely, reflect the inter-annual 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 1990-2011 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 of the National Food Chain Safety Office. Experts of the Directorate participated in a training earlier 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 knowledgeable about the needs, method and challenges of the development of the inventory. Some data and experience of the Hungarian Forest Research Institute, as well as the Institute of Site Fertility of the West-Hungarian University, were also incorporated in the GHG inventory.

#### **11.3.1.7 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 11.10 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 11.10** *Time limits of completing regenerations and afforestations (years after the area becomes subject to regeneration, e.g. after clear-cutting).*

Species and origin	Time limit (years) for regeneration type: shelterwood cutting or selection cutting
Quercus pubescens, seed origin	12
Quercus petraea, seed origin	10
Quercus robur, seed origin	
Quercus farnetto, seed origin	
Fagus silvatica, seed origin	
Other species, seed origin	8
	Time limit (years) for other types of regeneration
Quercus pubescens, seed origin	14
Quercus petraea, seed origin	12
Quercus robur, seed origin	
Quercus farnetto, seed origin	
Fagus silvatica, seed origin	
Coniferous sp.	10
Quercus cerris, seed origin	
Other hard broadleaves, seed origin	
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 11.11 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 five-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”, and the same thresholds and criteria are in effect for a regenerated area as for an afforested area (see section 11.4.2 and Table 11.10 above, and section 7.3.3 of the NIR). Thus, the above mean length of period of five-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 11.11** *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
2011	131 453
2012	141 205

#### 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 11.12 below.

**Table 11.12** *The amount of harvests for units of AR land that have been harvested (2008-2012).*

Reporting year	Geographical location	Amount of harvests (m <sup>3</sup> )
2008	North Hungary	17 730
	South Hungary	70 125
	Total	87 855
2009	North Hungary	19 395
	South Hungary	98 001
	Total	117 396
2010	North Hungary	31 279
	South Hungary	83 494
	Total	114 773
2011	North Hungary	32 256
	South Hungary	101 524
	Total	133 780
2012	North Hungary	37 325
	South Hungary	96 382
	Total	133 707

## 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 did not elect either 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, 2010 and 2011.

## 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>		
							N <sub>2</sub> O	N <sub>2</sub> O	N <sub>2</sub> O	CO <sub>2</sub>	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	IE			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	IE	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	170.05	0.00						170.05
	Deforestation		9.36						9.36
Article 3.4 activities	Forest Management (if elected)		0.78	1,655.41					1,656.19
	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>		1.16	0.00	0.00	NA	NA	NA	7,466.50	7,467.67
Total area at the end of the current inventory year		171.21	10.14	1,655.41	NA	NA	NA	7,466.50	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_2014_1_10-58-8 13-1-2014.xls].  (Report R-1) An updated SEF report has been submitted as well; the filename is: [SEF_HU_2014_2_12-33-47 23-4-2014.xls] An updated SEF report has been submitted as well; the filename is: [SEF_HU_2014_2_12-33-47 23-4-2014.xls]
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	There have been 40 discrepant transactions during the reporting period, pursuant to 15/CMP.1 annex I.E paragraph 12.  The response code was 7367 in all cases.  All transactions were attempted surrender of Kyoto units (ERUs or CERs), but the EUTL rejected them as all being initiated after 30.04.2013.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2013.  The above statement can also be found in the Excel file named [SIAR Reports 2014-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 2013.  The above statement can also be found in the Excel file named [SIAR Reports 2014-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 2013.  The above statement can also be found in the Excel file named [SIAR Reports 2014-HU v1.0.xls] on sheet "R5". (Report R-5)
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No discrepancies have occurred in the reporting period.
15/CMP.1 annex I.E Publicly accessible information	Publicly available information accessible on the website of the Hungarian National Registry are the following:  - Account information detailed in 13/CMP.1 par. 45 are available at: <a href="http://www.orszagoszoldhatosag.gov.hu/forgalmijegyzezsamlaa.datok.php?menu=123">http://www.orszagoszoldhatosag.gov.hu/forgalmijegyzezsamlaa.datok.php?menu=123</a>  - Article 6 project information detailed in 13/CMP.1 par. 46 are available at: <a href="http://www.orszagoszoldhatosag.gov.hu/jiprojektekadatai.php">http://www.orszagoszoldhatosag.gov.hu/jiprojektekadatai.php</a>  - Holding and transaction information detailed in 13/CMP.1 par. 47 are available at:

	<a href="http://www.orszagoszoldhatosag.gov.hu/egyenlegestranzakciokatok.php">http://www.orszagoszoldhatosag.gov.hu/egyenlegestranzakciokatok.php</a>  - List of legal entities authorized by party detailed in 13/CMP.1 par. 48 is available at: <a href="http://www.orszagoszoldhatosag.gov.hu/szamlaeski bocsatasiegysegtipusok.php">http://www.orszagoszoldhatosag.gov.hu/szamlaeski bocsatasiegysegtipusok.php</a>
15/CMP.1 annex I.E paragraph 18 CPR Calculation	The commitment period reserve is calculated in accordance with the annex to decision 18/CP.7, based on the inventory of 2012 (NIR submission 2014)  Please see Ch 12.1 for CPR and details of the calculation.

## 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 2011 (National Inventory Submission 2013). However, the inventory of 2012 (National Inventory Submissions 2014) is already available and by the time this document will be assessed, the inventory of 2012 might already be the "most recently reviewed inventory", so CPR is calculated based on 2012'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 2012 (NIR 2014)  
 five times the inventory of 2012:  
 $61,980,663 \times 5 = \mathbf{309,903,315 \text{ Mg CO}_2\text{-eq}}$

## 12.2. KP-LULUCF accounting

Based on the latest SEF report, Hungary has issued 8,796,303 RMUs.

Hungary's annual review report for the 2013 submission has been published at 21<sup>st</sup> May 2014. The accounting of RMU based on the 2013 submission will be taking place after the publication of the review report for the submission of 2013.

Altogether, based on the latest KP-LULUCF inventory, Hungary expects to be able to issue 11,395,353 tonnes CO<sub>2</sub> equivalent as RMUs and cancel 438,104 AAUs due to activities in the period 2008-2012 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 2012  
Submission 2014 v2.1  
Number of the reported year in the commitment period: 5

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	BY(S)	Net emissions/removals(1) (Gg CO <sub>2</sub> equivalent)					Accounting Parameters <sup>(3)</sup>	Accounting Quantity <sup>(4)</sup>
		2008	2009	2010	2011	2012		
<b>A. Article 3.3 activities</b>								
<b>A.1. Afforestation and Reforestation</b>								
A.1.1. Units of land not harvested since the beginning of the commitment period <sup>(2)</sup>		-1 130,17	-1 103,09	-1 206,00	-1 130,36	-1 042,45	-5 602,07	-5 602,07
A.1.2. Units of land harvested since the beginning of the commitment period <sup>(2)</sup>								
<i>Southern-Hungary</i>		-21,39	-36,98	-69,25	-99,57	-143,87	-371,06	-476,62
<i>Northern-Hungary</i>		-4,03	-9,20	-13,14	-33,20	-43,27	-103,20	-371,06
<i>All regions</i>		IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO
<b>A.2. Deforestation</b>		51,41	89,57	48,53	70,45	178,14	438,10	438,10
<b>B. Article 3.4 activities</b>								
<b>B.1. Forest Management (if elected)</b>		-2 767,91	-1 875,71	-1 663,59	-1 506,90	-2 353,32	-10 167,62	-5 316,67
3.3 offset <sup>(3)</sup>								0,00
FM cap <sup>(4)</sup>								5 316,67
<b>B.2. Cropland Management (if elected)</b>	0,00	NA	NA	NA	NA	NA	NA	0,00
<b>B.3. Grazing Land Management (if elected)</b>	0,00	NA	NA	NA	NA	NA	NA	0,00
<b>B.4. Revegetation (if elected)</b>	0,00	NA	NA	NA	NA	NA	NA	0,00

### 13. Information on changes in national system

The Government Decree 345/2009 (XII.30) on data provision in relation with greenhouse gases has been replaced by Govt. Decree 528/2013 (XII.30.) according to the changing EU regulations and reporting needs. For this inventory submission, however, the rules of the previous government decree still applied.

The Forest Research Institute became part of the newly established National Agricultural Research and Innovation Centre (NARIC).

### 14. Information on changes in national registry

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time the EU Member States decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR). Following the successful implementation of the CSEUR platform in June 2012 all EU Member States switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the national registry of Hungary have occurred in 2013:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The name of the Registry Administrator organization has changed from 'National Inspectorate for Environment, Nature and Water' to 'National Inspectorate for Environment and Nature'. Contact information of the registry administrator has also changed. For details please see details below this table
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change in 2013 regarding the cooperation agreement  The EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway have decided to operate their registries in a consolidated manner. The Consolidated System of EU registries was certified on 1 June 2012 and went to production on 20 June 2012.

Reporting Item	Description
<p>15/CMP.1 annex II.E paragraph 32.(c)</p> <p>Change to database structure or the capacity of national registry</p>	<p>An updated diagram of the database structure is attached as Annex A. Iteration 5 of the national registry released in January 2013 and Iteration 6 of the national registry released in June 2013 introduces changes in the structure of the database.</p> <p>Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan.</p> <p>No change to the capacity of the national registry occurred during the reported period.</p> <p>[Annex A filename: Annex A - CSEUR_DB_model_20140114.pdf]</p>
<p>15/CMP.1 annex II.E paragraph 32.(d)</p> <p>Change regarding conformance to technical standards</p>	<p>Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality.</p> <p>However, each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was carried out in February 2014 and the successful test report has been attached (see Annex C).</p> <p>No other change in the registry's conformance to the technical standards occurred for the reported period.</p> <p>[Annex B filename: Annex B - CR2013-v5 2- v6.1.7.1 REPORT-v3 00.xlsx]</p> <p>[Annex C filename: Annex C - AnnexH test results EU.docx]</p>
<p>15/CMP.1 annex II.E paragraph 32.(e)</p> <p>Change to discrepancies procedures</p>	<p>No change in the discrepancies procedures in the reporting period.</p>
<p>15/CMP.1 annex II.E paragraph 32.(f)</p> <p>Change regarding security</p>	<p>No change in the security in the reporting period.</p>
<p>15/CMP.1 annex II.E paragraph 32.(g)</p> <p>Change to list of publicly available information</p>	<p>No change in the list of publicly available information in the reporting period.</p> <p>Information regarding publicly available information is available at: <a href="http://www.orszagoszoldhatosag.gov.hu">www.orszagoszoldhatosag.gov.hu</a></p>
<p>15/CMP.1 annex II.E paragraph 32.(h)</p> <p>Change of Internet address</p>	<p>No change in the internet address in the reporting period.</p> <p>The internet address of the Hungarian registry is:</p> <p><a href="https://ets-registry.webgate.ec.europa.eu/euregistry/HU/index.xhtml">https://ets-registry.webgate.ec.europa.eu/euregistry/HU/index.xhtml</a></p>

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change in the data integrity measures in the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B.  Annex H testing was carried out in February 2014 and the successful test report has been attached (see Annex C).
The previous Annual Review recommendations	Please find responses to the recommendations of the previous Annual Review recommendations in the table below.

Reference	Recommendation description	Response
P.1.4.1– P.1.4.4	The assessor notes that the web address as provided in the Hungarian NIR does not display any public information. The assessor recommends that Hungary make the public information as required by decision 13/CMP.1 Annex paragraph 44-48 available.  The assessor recommends that Hungary includes public information directly on the website of the national registry or via a link from the registry website to another website controlled by the Party. The assessor recommends that the publicly available information be up to date (i.e. updated as close to real time as possible, but at least updated on a monthly basis).	Publicly available information is available at: <a href="http://www.orszagoszoldhatosag.gov.hu">www.orszagoszoldhatosag.gov.hu</a>  Information is updated on a monthly basis.  The URL where the public information is available has been placed onto the registry website.
2.3.3	The assessor recommends that following major changes, the party provide a data model which contains all DES required entities complete with descriptions in its annual NIR.	The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. Since the successful certification of the registry on 1 June 2012, Iteration 4 of the registry, introduced in October 2012, added a limited number of new entities, none of them relating to DES entities.  A data model was attached which more clearly shows

		<p>the relevant entities "RECONCILIATIONS", "NOTIFICATIONS", "RESPONSES", "INTERNAL AUDIT LOG" and "MESSAGE LOG." As specified in the DES (Section VII. Data Logging Specifications/E. Message Archive), a copy of messages sent and received is stored in standalone files in one of two managed servers in the hosting environment. For that reason, the Message Archive is not shown in the model. The "MESSAGE LOG" object holds the location of the entire message, for each Message_ID.</p> <p>Since the successful certification of the registry on 1 June 2012, there has been no change in the capacity of the registry or change of its infrastructure.</p>
2.3.10	<p>The assessor strongly recommends that the Party test each release thoroughly against the DES as part of each major release cycle and provide the results of such tests in its annual NIR.</p>	<p>The consolidated EU system of registries successfully completed a full certification procedure in June 2012. Notably, this procedure includes connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). This included a full Annex H test. All tests were executed successfully and led to successful certification on 1 June 2012.</p> <p>The October 2012 release (version 4.0) was only a minor iteration and changes were limited to EU ETS functionality and had no impact on Kyoto Protocol functions in the registry. The test script previously provided reflects this.</p> <p>However, each major release of the registry is subject to both regression testing and tests related to new functionality. These tests include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production.</p>

### Contact information of the registry administrator

The primary contact is:

Name: dr. Zoltán Szentmiklóssy.  
 Position: General Manager  
 Organization: National Inspectorate for Environment and Nature  
 Address: Mészáros utca 58/a  
 City: H-1016 Budapest  
 Tel.: +36 12 24 9100  
 Fax: +36 12 24 9264  
 E-mail: [szentmiklossyz@oktvmf.gov.hu](mailto:szentmiklossyz@oktvmf.gov.hu)

Further contacts are:

Name: Ms. Livia Víg  
 Position: Head of Department  
 Organization: National Inspectorate for Environment and Nature  
 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.”

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.